EFFECTS OF AN AUDITORY-BASED 15-MINUTE DAILY ONLINE MINDFULNESS INTERVENTION ON COGNITIVE PROCESSING, SOCIO-AFFECTIVE FUNCTIONING, AND DISPOSITIONAL MINDFULNESS

by

Jordan S. H. Thomson

Department of Psychology

Submitted in Partial Fulfillment

of the requirements for the degree of

Bachelor of Arts

in

Honours Psychology

Faculty of Arts and Social Science

Huron University College

London, Canada

April 20, 2023

HURON UNIVERSITY COLLEGE

FACSIMILE OF CERTIFICATE OF EXAMINATION
(The Original with Signatures is on file in the Department)

Advisor: Dr. Stephen Van Hedger

Reader: Dr. Melissa Meade

The thesis by:

Jordan S. H. Thomson

entitled:

Effects of An Auditory-Based 15-Minute Daily Online Mindfulness Intervention on Cognitive Processing, Socio-Affective Functioning, and Dispositional Mindfulness

is accepted in partial fulfilment of the requirements for the degree of

Bachelor of Arts

in

Honours Psychology

April 20th, 2023
Date

Dr. Christine Tsang
Chair of Department

Abstract

Mindfulness-based interventions (MBIs) are linked with improved cognitive functioning and biopsychosocial wellbeing, and changes in trait-level personal characteristics, especially dispositional mindfulness (DM) and metacognition. Traditional MBIs are effective but resource intensive for practitioners and instructors. Brief online MBIs have been shown to be effective – but there is ambiguity over how online MBIs are effective and for whom. The present research investigated the effects of a brief daily online MBI on cognitive performance (working memory, long-term memory, attention, executive inhibition), socio-affective functioning (depression, anxiety, stress), and individual differences in DM, trait metacognition, and Big Five individual difference factors. Subjects completed pre- and post-intervention online testing batteries measuring our variables of interest and were randomly assigned to complete either a mindfulness experimental intervention or podcast control intervention for 15 minutes daily, for 31 days. The mindfulness group increased in dispositional and state mindfulness and relaxation relative to the podcast group. In addition, the podcast and MBI groups both increased in working memory performance and trait metacognition, and decreased in depression, anxiety, and stress from pre- to post-intervention testing. Additionally, significant correlations between mindfulness and metacognition suggested the two are distinct but related constructs which may be underpinned by a single latent factor related to adaptive functioning. Limitations and future directions are discussed. Overall, these results suggest that a 15-minute daily online MBI can selectively facilitate greater relaxation and mindfulness; however, general effects for both interventions observed from pre- to post-intervention testing highlight the importance of designing appropriate controls in mindfulness-based research.

Keywords: mindfulness, metacognition, online, intervention, university, working memory, long-term memory, attention, inhibition, depression, anxiety, stress, individual differences

Acknowledgements

First and foremost, I wish to acknowledge and express my gratitude to Dr. Stephen Van Hedger for the instrumental (and considerable) work he contributed to this project in coding the testing and analyses, as well as the exceptional feedback and insight he contributed all throughout the year as he helped this project take shape. The immense value you added to this project is greatly appreciated.

I am also indebted to Dr. Melissa Meade for being my second reader and contributing her valuable feedback along the way, which substantially helped improve the quality of the final results and interpretations herein.

I must also sincerely thank Seth Zarkovich and Matthew Jarvis, who were both instrumental in helping the online web module come together. Thank you both sincerely for the hours of coding, meetings and other hard work that went into making the final website come together and launch and deploy successfully. Thanks also to Seth for his contributions in preparing for my thesis defence and in making my data interpretation a bit sharper – as well as all for our philosophical, psychological, and scientific discussions.

Finally, I wish to express my love and thanks to my family for their support and time sacrificed with me so that I could diligently work on bringing this project together. Thank you to Dani, Adri, Hunter, and my mom and dad for all their instrumental help in seeing me achieving my goals, both academic and otherwise.

Table of Contents

Introduction

Different mindfulness techniques and training methods have become increasingly popular in modernity, while having roots in Eastern Buddhist and similar ancient traditions and philosophies (Kang & Whittingham, 2010; Sellars, 2018). Recently, there is a growing body of online mindfulness-oriented self-help articles, websites, and YouTube channels. Likewise, a variety of digital mindfulness tools are cropping up on app stores (Lukoff et al., 2020), and stand-alone web interventions are also being empirically investigated and developed (e.g., Bremer et al., 2022; Cavanagh et al., 2013). Traditional MBIs which are longer in duration (and more resource intensive) have been shown to be effective in decreasing stress, anxiety, and depression – thereby increasing biopsychosocial wellbeing in both clinical and healthy adult populations (Chiesa & Serretti, 2009, 2011). Recent research also shows the beneficial effects of briefer MBIs on cognitive processing, mood, and dispositional mindfulness (e.g., Zeidan et al., 2010), including those delivered online (Bremer et al., 2022; Spijkerman et al., 2016). However, mixed results exist regarding the effects of MBIs on cognitive performance, and it remains unclear precisely for whom, under what conditions, and by what mechanisms MBIs influence cognition and affect. The present study contributes to this growing empirical body by assessing the effects of an adapted, standardized 15-minute daily, 31-day online mindfulness training intervention on cognitive processing (working and long-term memory, attention, and executive inhibition), socio-affective functioning (depression, anxiety, and stress), and individual differences (mindfulness, metacognition, and Big Five traits) in a sample of university students.

Conceptualizing Mindfulness

Ideal mindfulness meditative practice is based around two core principles: (i) focused attention on and awareness of the inner and outer contents of present moment experience; and (ii) aware, non-judgmental, radically non-reactive acceptance of emotions, cognitions, and experiences (Brown & Ryan, 2003; Bishop et al., 2004). The mindful individual is thus focused on and aware in the present moment, open to novelty, sensitive to changes in context, and

aware of multiple perspectives (Gallant, 2016). They can regulate their emotions through enhanced emotional acceptance, nonjudgment, nonreactivity and mindful presence in the moment (Vøllestad et al., 2012). These skills are frequently cultivated through regular mindfulness meditative practice – which doesn't necessarily require a formal protocol and may be effectively employed by the novice (Edenfield & Saeed, 2012; Cavanagh et al., 2013).

Discussions of mindfulness may be framed in several ways which are fundamentally intertwined, leading to confusion about the meaning of the term. Thus, we distinguish here between two intimately related conceptualizations of mindfulness: (i) mindfulness as a practice (MP) and mindfulness training (MT) protocols, which implicitly characterize mindfulness as a learned and developed skill (broadly, the mindfulness-based intervention, or "MBI", conception); and (ii) mindfulness as a neurobiologically rooted trait and its related cognitive-behavioural constructs and dispositions (the "dispositional mindfulness" conception). Critically, discussions of MBIs and dispositional mindfulness go together: consistently enacted MBIs/MP lead to demonstrable changes and improvements in dispositional mindfulness (Chiesa et al., 2011; Kiken et al., 2015), which are related to health, wellbeing, and cognitive performance improvements (Chiesa & Serretti, 2009).

Mindfulness-Based Interventions (MBIs)

At one level, we may regard the term mindfulness as a practiced behavioural and (meta)cognitive self-regulation skill which is cultivated through disciplined training protocols and consistent meditative practice. MT and MP are typically integrated into formal MBI systems or protocols. MBIs integrally involve training in, and ongoing regular practice of, formal mindfulness protocols or techniques that are usually created by expert mindfulness practitioners, clinicians, or researchers. MBIs seem to exert their effects via trained and practiced state-level behavioural and neurophysiological changes to dispositional mindfulness, which become more crystallized and habituated over time via changes to neural morphology and connectivity. For instance, Bremer and colleagues (2022) showed alterations in neural functional connectivity after just 31

days of a brief online daily MBI (see also Sezer et al., 2022), and Tang and colleagues (2015) describe various studies showing MBI-related changes in diverse neural grey matter regions after mindfulness meditative training, from both brief and longer-term practice durations.

MBIs typically involve training a process of decentering attention away from runaway active thoughts (mind wandering), instead conscientiously and continually recentering attentional focus onto present moment awareness. In other words, one cultivates the ability to observe and let go of thoughts and emotions as they arise, and rest in awareness of the contents of present, moment-to-moment experience. Critically, this is paired with cultivation of non-judgmental acceptance of the present moment's contents as beyond one's full control (Gallant, 2016). Ideally, these two core components lead to a moment-to-moment (and eventually enduring) cognitive reframing of subjective perceptions, cognitions, and emotions, as well as increased cognitive and behavioural control. Moreover, such sustained practice leads to a fundamentally altered way of interacting with and relating to present moment experience, through skilled cognitive-experiential monitoring and acceptance (Lindsay & Creswell, 2017). This entails correlated neural restructuring (see Bremer et al., 2022; Tang et al., 2015), which often carries benefits for subjective health, wellbeing, performance, and quality of life (Lomas et al., 2019; Kersemaekers et al., 2018).

Importantly, trait-level (dispositional) changes are possible through repeatedly practicing a state-level cognitive mode of mindfulness according to the above principles. This dispositional shift in mindfulness involves a gradual, day-to-day baseline experiential and perceptual shift towards a default "mindfulness mode", away from typical "default mode" mind wandering, entailing corresponding neuroplastic alterations with disciplined practice. While this logic is often presumed theoretically, it has recently gained further explicit empirical support (e.g., Kiken et al., 2015; see also Esch, 2014). Bremer and colleagues (2022) also plausibly suggest that MBI-related increases in connectivity between the default mode and salience networks reflect mindfulness practitioners becoming more aware of (and differentially oriented towards) default

mode-related mind-wandering and self-referential processing (i.e., becoming more mindful; see also Farb et al., 2007). This is particularly relevant to our present research, as our MBI is structurally quite similar to that administered by Bremer and colleagues.

Developing an Effective Brief Standardized Online MBI. While encouraging, recent surging interest in mindfulness highlights the need for standardized, effective, practical, and easily accessible mindfulness-based interventions (MBIs) for the 21st century, which have demonstrable real-world efficacy across diverse contexts and populations. There is presently wide variation in training and practice protocols – and having a standard and optimized MBI which can be deployed by clinicians and novices alike is ideal.

Somewhat problematically, many current and well-validated MBIs are administered by an in-person instructor over the course of many weeks (e.g., Isbel & Summers, 2017; Mindfulness-Based Stress Reduction, or MBSR, see Kabatt-Zinn 2011 and Santorelli et al., 2017; Mindfulness-Based Cognitive Therapy, or MBCT, see Segal et al., 2018) or during an intensive in-person retreat (e.g., Sahdra et al., 2011). Moreover, they typically require substantial daily time commitments from participants and attendance of in-person classes for several hours per week. The time and other resource investments required for participation and administration of such protocols are considerable and often prohibitive – and thus present key barriers to possible initiation and maintenance of mindfulness practice. This was a partial impetus for our present experiment's shorter adapted intervention.

Another issue is that mindfulness protocols are highly heterogenous in their methods and how they are applied (Chiesa & Malinowski, 2011). Moreover, there are relatively few specialized instructors for each protocol, leading to a scarcity of availability of courses. Thus, taken together with the other noted issues, it's impractical to hope for such interventions to catch on more ubiquitously, which limits our ability to understand more generalizable and widespread benefits of MBIs.

Isbel and Summers (2017) offer a standardized mindfulness framework to ameliorate some of the issues present in mindfulness research. Their MBI is a high-fidelity adaptation of MBSR, standardized in such a way that it could be applied reliably and repeatedly to randomized controlled trials (RCTs) across contexts. Their goal was to address heterogeneity in MBI research paradigms, reducing the methodological variety which contributes to ambiguity over various MBIs' particular efficacy and mechanisms. Importantly, while this sufficiently addresses several research-focused methodological issues and limitations of traditional mindfulness research paradigms, this MBI still requires an 8-week commitment to in-person classes and at-home practice, and thus is insufficient to overcome several key barriers to more widespread public and clinical adoption of mindfulness practice.

Many researchers have recently investigated the limitations and constraints of MBIs and two general trends emerge. Firstly, research shows that we may successfully reduce the daily and overall required amount of practice time and still reap benefits. For example, a recent study by Bremer et al. (2022) effectively used a 31-day, 10 to 15 min/day online MBI and demonstrated functional connectivity changes in salience, default mode, and central executive neural networks – suggesting a potential "triple network" mechanism underlying mindfulness training and practice, which is altered after as little as 10-15 minutes of daily practice. Moreover, a recent review of short-term interventions less than 8 weeks and more than 3 days showed promising effects of MBIs on executive functioning (Zhou et al., 2020). Zeidan et al. (2010) demonstrated that after just 4 days of in-person mindfulness training sessions subjects experienced mood improvements, including reduced fatigue and anxiety, and increased mindfulness. Further, this brief intervention improved visuo-spatial processing, working memory, and executive functioning, extending the benefits of this short-term mindfulness training to cognitive performance. Finally, Gorman and Green (2016) showed that after just a single session of brief, repeated, intermittent exposures to either mindfulness techniques or web browsing, the mindfulness group showed enhanced attentional control relative to the web

browsing group. Thus, benefits from mindfulness practice may be seen in as little as one session involving brief, intermittent applied mindfulness – and as little as 10-15 minutes per day of more regularized practice is sufficient to induce neuroplastic (and concomitant behavioural) alterations within and across individuals. These and other results seriously call into question the necessity of lengthier interventions requiring many hours of weekly training and practice.

Secondly, we may be much more flexible in our delivery mechanism for mindfulness instruction and training, while still preserving the salutary effects of MP. Research shows it's possible to loosen in-person class structures to instead deliver more targeted and convenient MBIs. Importantly, research shows that MBIs may be delivered via modularized online instruction that does not require mindfulness practitioners. Again, the Bremer et al. (2022) study's protocol offers a viable prototypical intervention structure for an online MBI (10-15 mins/day for 31 days). Such a structure allows for the habituation of mindfulness behaviours over extended time through brief, digestible doses of regular daily practice. Studies by Krusche and colleagues (2012, 2013) across hundreds of self-referred participants deployed an online MBI and demonstrated decreases across subjects in perceived stress, anxiety, and depression post-intervention and at one-month follow up – and importantly, effect sizes were comparable to those of face-to-face MBIs and CBT interventions. A 2016 review and meta-analysis of RCTs deploying online MBIs showed that online interventions have significant small-to-moderate effects on mental health and subjective wellbeing (Spijkerman et al., 2016). Finally, Cavanagh et al. (2013) showed that a brief online MBI was effective at increasing mindfulness and decreasing perceived stress, anxiety, and depression symptoms. These and other similar results demonstrate that we may productively remove cumbersome in-person class instruction requirements of traditional MBIs while preserving intervention quality and related benefits of MT/MP.

Taken together, these results strongly support the notion that we may fruitfully modify existing, empirically validated MBIs to minimize required time and other resource investment,

while maximizing the ameliorative benefits to mindfulness meditation practitioners. This endeavor may help reduce barriers to entry for would-be practitioners, while also enhancing the quality of mindfulness practice for current practitioners – thus serving to promote more widespread adoption of beneficial mindfulness practice across diverse populations.

Dispositional Mindfulness and MBIs Related to Enhanced Cognition

Dispositional mindfulness and MBIs are associated with better cognitive outcomes. For instance, a review by Chiesa and colleagues (2011) outlines preliminary evidence for several cognitive benefits of mindfulness training programs. In general, mindfulness as a trait and practice has been reported to have positive influences across diverse measures such as working (WM) and long-term memory (LTM); executive functioning, or more specifically executive inhibition (EI) and attention; socio-affective functioning; self-regulation; and overall negative affect, both trait- and state-level (Gallant, 2016; Chiesa & Serretti, 2009; 2011).

Regarding WM, several brief MBIs have been demonstrated to positively influence WM (Zeidan et al., 2010, Mrazek et al., 2013). Mrazek et al. (2013) found that mindfulness training improved reading comprehension scores and WM capacity, with improvements in performance mediated by reduced mind wandering. Alternatively, a study by Banks and colleagues (2015) found that mindfulness meditation reduced stress-related WM impairments but did not increase WM capacity nor decrease mind wandering. Importantly, there is controversy over exactly how mindfulness may impact WM capacity or functioning. Jha et al. (2019) suggest that MP protects and strengthens the neural processes underlying WM; when WM function is enhanced through MP, the myriad processes contributing to our high-integrity mental ‘scratch space’ also benefit. In contrast, Banks et al. (2015) suggest that MP does not increase WM or decrease mind-wandering, but instead may buffer against stress-related WM impairments – which accords with Creswell and Lindsay’s (2014) stress-buffering account of mindfulness. The debate continues – and our present study hopes to help clarify by including WM as a variable of interest.

Regarding LTM, evidence also shows a positive relationship with MP. Brown et al. (2016) cleverly showed across three studies an effect of mindfulness on episodic LTM: self-reported mindfulness predicted better recognition performance; focused attention training produced better recognition memory relative to an active control; and the effect of MP generalized to free recall. Shemesh et al. (2022) found evidence for long-term mindfulness practitioners' enhanced declarative memory; moreover, they found that trait mindfulness positively correlated with declarative memory performance as a function of MP. Austin and Loprinzi (2019) showed that exercise together with MP led to a superior effect on LTM function, suggesting that acute exercise prior to encoding and meditation during early consolidation may lead to enhanced LTM. One possibility is that, like with WM, mindfulness might influence LTM through reductions in stress, depression, and anxiety, which may lead to improved cognitive processing and performance (e.g., Lukasik et al., 2019; Maramis et al., 2021). Alternatively, mindfulness-specific enhancements to executive-attentional and affective neural systems related to memory – and concomitant shifts in dispositional mindfulness and metacognition – could also be involved.

Regarding EI and attention, myriad studies show clear evidence for enhanced domain-general executive inhibition capacities (Miyake et al., 2000; Friedman & Miyake, 2017) related to MBIs and mindfulness (Chiesa et al., 2011; Sahdra et al., 2011). Allen and colleagues(2012) showed EI improvements on an affective Stroop Task after mindfulness training. A study by Sahdra et al. (2011) looked at a latent variable called "adaptive functioning" (AF) underlying a multitude of emotional, cognitive, and other individual difference factors – including EI as measured by a lengthy response inhibition task (RIT). Their mindfulness retreat group saw significantly improved AF relative to a wait-list control – and the control group experienced similar results when administered the same MBI. Many studies also show robust support for a positive relationship between mindfulness and emotional-cognitive self-regulation, as well as decision making (e.g., Allen et al., 2012; Sun et al., 2015; Bao et al., 2015; Jha et al., 2019;

Jiménez-Picón et al., 2021). Isbel et al. (2020) found that a standardized MBI (upon which our 31-day online MBI was based) was effective in improving executive inhibition and attentional resource allocation in older adults on a Sustained Attention to Response Task (SART). Tang and colleagues (2007) also showed that a short-term MBI involving only 20 minutes of practice daily for five days led to improved attention and self-regulation as measured by the Attention Network Test (ANT), and decreased stress as measured by both self-report and salivary cortisol. Lastly, dispositional mindfulness and MP have been found to attenuate cognitive-emotional attentional blink (Makowski et al., 2019; Wang et al., 2022).

Mindfulness and Metacognition: Distinct but Overlapping

Dispositional mindfulness is entangled with another cognitive construct and trait: metacognition. Metacognition is thinking about thinking (Shute, 2019), or 'cognition applied to cognition' (Solem et al., 2015, p. 2), and involves awareness or analysis of one's own learning and thinking (Merriam-Webster, n.d.). Mindfulness practice has been described as a fundamentally metacognitive exercise (Kudesia, 2019; 2020), and trait mindfulness and metacognition seem ubiquitously related.

In support of this idea, Jankowski and Holas (2014) propose a multi-tiered metacognitive model of mindfulness. They suggest that mindfulness relates to the highest levels of metacognition – and metacognitive knowledge about oneself promotes mindfulness. Mindfulness practice promotes extension of one's metacognitive abilities to gain overarching insights derived specifically from a cultivated state of mindfulness and enables the intentional evoking and refreshing of mindfulness mode.

Despite empirical support for their definitional and statistical overlap, it remains unclear exactly how these two are distinct cognitive constructs. Solem et al. (2015) offer some evidence of how mindfulness and metacognition are distinct – but generally, results are sparse and unclear. Our present study thus also hopes to help clarify how mindfulness and metacognition are distinct yet related.

The Present Research

Considering the myriad positive effects of MBIs on cognitive performance, health, and wellbeing – and particularly in reducing stress, anxiety, and depression – university students represent a prime target intervention demographic for MBIs, as they have ongoing environmental cognitive performance demands which may benefit substantially from MP. In modernity, many university campuses offer MT, mindfulness-oriented counseling or therapy, or general mindfulness learning materials. Considerable research suggests that university students may benefit from MBIs (Dawson et al., 2020; Ramler et al., 2016), and higher dispositional mindfulness may help with stressful university adjustments (Mettler et al, 2019). Moreover, university students commonly experience stress and burnout (Robotham & Julian, 2006; Robins et al., 2018) – and MBIs have been demonstrated as effective in reducing burnout in stressful environments (Vella & McIver, 2019; Green & Kinchen, 2021). Given the amount of time university students spend online (Odell et al., 2000; Chen & Peng, 2008) a digital module involving online instruction and delivery seems to be a prime channel for delivery of an MBI to university students.

Moreover, to increase the likelihood of broader adoption of mindfulness practice, it's reasonable to wonder whether we may reduce the time and other resource investments involved in traditional MBIs without affecting the quality of our outcomes – thereby mitigating barriers to entry to mindfulness practice. It's equally relevant to ask how we might remove the restrictive in-person class instruction requirements – especially considering recent COVID-19 pandemic restrictions, and an increasingly globalized digital world wherein practitioners more commonly deliver online services, including psychotherapy (e.g., see Andersson et al., 2010; Andersson & Cuijpers, 2009).

Present Experiment: 31-Day, 15-Minute Daily Online MBI

Our experiment investigated the effects of a standardized daily online MBI involving 15 minutes per day of auditorily-guided mindfulness meditation for a total of 31 days. This adapted

MBI was compared to an active control group exposed to a daily 15-minute snippet from one of four educational podcast episodes discussing neuroscientific tools for health and wellbeing unrelated to mindfulness. Our sample included undergraduate- and graduate-level university students – a prime target demographic for MBIs. We sought to validate the efficacy of our adapted 15-minute, 31-day online MBI, given the success of its more elaborate 8-week inspiration (Isbel & Summers, 2017). Moreover, we sought to help clarify the relationship between mindfulness and metacognition – including the specific nature of their correlation, and whether they are in fact distinct or a unitary construct. Finally, we hoped to offer provisional and informative answers to some guiding research questions outlined below.

Experimental Hypotheses

Some key research questions which guided the present inquiry include: (i) Is our adapted, standardized, brief daily online MBI effective in improving cognitive performance, socio-affective functioning, and dispositional mindfulness? (ii) Does training through our MBI induce state-level shifts in dispositional mindfulness, and does this lead to enduring trait-level changes? (iii) Are mindfulness and metacognition distinct cognitive constructs (i.e., are they statistically independent or overlapping), and how are they similarly or differentially influenced by our MBI?

Our experimental hypotheses were (i) generally, relative to our active podcast-listening control group, that our 31-day online MBI would improve scores across our basket of measured variables (measures both before and after the intervention), in line with prior research; (ii) specifically, that the MBI would improve cognitive task performance scores similarly across WM, LTM, attention, and EI tasks; moreover, (iii) that the MBI would have an ameliorative influence on measures of depression, anxiety and stress; also, (iv) that the MBI would lead to increased state mindfulness and metacognition, and (v) to increased trait mindfulness and metacognition.

Method

Participants

Participants for this study were recruited from a pool of undergraduate and graduate students across all disciplines at Huron University and Western University in London, Ontario, Canada. Recruitment was conducted at several locations on campus via posters, word of mouth, and several days of active in-person recruiting by a principal researcher. Recruitment materials were also disseminated across university-related Facebook and Instagram pages and groups. Prospective participants were offered monetary compensation for successful completion of various stages of the project: (i) the pre-intervention testing; (ii) the active 31-day intervention; and (iii) the post-intervention testing. They were also screened for prior practice with mindfulness or meditation to ensure that all participants were meditation-naïve.

Recruitment efforts targeted a minimum of 30 total subjects (15 per group). Initial recruitment efforts yielded 64 individuals. Overall, attrition rate was relatively high and approximately 58% were retained for the full study duration – thus leaving 37 final participants (28 women, 7 men, 2 non-binary; Age *M* = 21.68 years, *SD* = 6.57 years, range of 18 to 49 years) who successfully completed the pre-intervention testing, 31-day intervention period, and post-intervention testing.

Finally, prior to commencing their testing and first daily sessions, participants were randomly assigned to one of two possible groups: either the mindfulness-based intervention experimental group (MBI group; 15 minutes of daily online mindfulness training and practice) or the podcast active control group (Podcast group; 15 minutes of daily online podcast listening).

Materials

Pre- and Post-Intervention Online Testing & Questionnaires

Participants completed an initial set of testing on a range of variables, including cognitive performance, socio-affective functioning, and individual differences measures. All testing was conducted online using various scripts programmed in jsPsych (de Leeuw, 2015) and designed

by a principal researcher. The components of the pre- and post-intervention testing are described in the subsequent subsections.

Cognitive Performance: Working Memory. Working memory (WM) was included because prior research has shown evidence for an effect of mindfulness practice on WM (e.g., Jha et al., 2019; van Vugt & Jha, 2011). It was tested using an N-back design (e.g., see Kane & Conway, 2016). Participants completed both a 1-back and 2-back task to test WM updating efficacy; the 1-back served as practice for the task, and the 2-back test served as the WM dependent measure. Letters were visually presented one at a time in sequence, with a new letter appearing every 3000 ms. Subjects were required to press a key (spacebar) when the current letter matched the letter previously presented either 1 or 2 spots back in the sequence for the 1- and 2-back, respectively. For example, given the sequence “M… D… P”, the subject would press the spacebar for the 1-back task only if the next letter presented were “P”, and for the 2-back task they would key press if the next letter presented were “D”. Participants completed four total blocks of the N-back (one block of a 1-back, meant to familiarize participants with the task, followed by three blocks of the 2-back, which were scored). Each block consisted of 30 letters (20 non-targets, 10 targets, in a randomized order). Accuracy, operationalized in terms of hits minus false alarms, and reaction times were recorded.

Cognitive Performance: Long-Term Memory. Long-term memory (LTM) was included because research has shown sparse but promising results indicating a beneficial effect of mindfulness on LTM (e.g., Austin & Loprinzi, 2019; Lykins et al., 2012). LTM was tested using a word recognition paradigm, which involved an initial word memory encoding phase at the beginning of the cognitive testing battery, and a subsequent word recognition phase that was presented later in testing. Non-presented lure words were presented alongside studied words to assess recognition memory. There were four lists of 25 words (A-D), generated specifically for this study, with two matched list pairs (A paired with B; C paired with D). Word lists were paired based on both structural and conceptual similarity of items (e.g., List A contained words such as

“apple,” “fist,” and “lemon,” whereas List B contained words such as “apricot,” “foot,” and “lime”). For example, if participants were presented with List B in encoding, they would be presented with all words from List A and B (in a randomized order) during recognition. Encoding list was counterbalanced across participants. All lists contained nouns that were statistically comparable in terms of concreteness ratings as well as estimated word frequency (Brysbaert & New, 2009). Hits, misses, correct rejections, and false alarms were recorded, and performance was operationalized in terms of hits minus false alarms.

Cognitive Performance: Executive Inhibition and Attention. Executive inhibition (EI) was included because MBIs have shown robust evidence for an influence on EI for both general cognitive (e.g., Gallant, 2016) and affective-cognitive (e.g., Allen et al., 2012) tasks. EI was tested using two different measures. The first was related to executive inhibition of emotional stimuli and involved administration of an affective Stroop task (Williams, Mathews, & MacLeod, 1996). Subjects were randomly exposed to an equal number of neutral-affect or negative-affect words derived from a subset of a standardized word database (Warriner et al., 2013); emotional valence of words in each category were selected to be equivalent. Participants were required to press a key corresponding to the colour of the word they were presented with (Red, Green, Blue, Yellow; R, G, B, Y keys, respectively). They were required to inhibit the distracting semantic-affective content of the word, instead tailoring attentional and behavioural responses to the colour identification task and pressing the appropriate key. Participants first completed a practice block (in which the text was a non-word: “XXXXX”) to become familiar with the key-colour mapping. Following this practice block, participants completed the main assessment, which consisted of 80 total words (40 neutral words and 40 negative words). Word category was blocked (either 20 neutral / 20 negative / 20 neutral / 20 negative or 20 negative / 20 neutral / 20 negative / 20 neutral) as blocking (rather than complete randomization) has been shown to increase affective related interference effects (Ben-Haim et al., 2016). Accuracy and reaction times were recorded.

An attention and EI task was also included as MBIs have been shown to improve both sustained and selective attention (Jha et al., 2007; Chiesa et al., 2011). The Sustained Attention to Response Task (SART; Robertson et al.,1997) measures both selective and sustained attention, and it further involves executive inhibition, thus offering a second proxy test of general cognitive (executive) inhibition.

The SART involved a computerized go/no-go task wherein participants were required to inhibit behavioural responses to distractor stimuli and pay sustained attention to the task over time in order to selectively attend to a target stimulus. Numbers 1 through 9 were briefly presented sequentially over several minutes. Subjects had to press the spacebar key when the number was anything other than 3 (i.e., 1, 2, 4, 5, 6, 7, 8, 9). When the number 3 appeared in the sequence, subjects had to inhibit their primed key-pressing response behaviour. Each number was presented for a brief period (250ms) and was immediately replaced by a fixation cross (1000ms); thus, the inter-trial interval was 1250ms. Participants had 1000ms to respond. If participants responded correctly, the fixation cross would turn green; otherwise, it would turn red. Participants completed a short practice block (18 numbers), followed by a longer main assessment (225 numbers). The main assessment lasted approximately eight minutes. Response times, and accuracy were recorded, and participants' commission errors (i.e., pressing spacebar when the number 3 was presented) was the primary dependent variable.

Individual Differences: Big Five Personality Traits. Individual differences in trait-level Big Five personality factors were measured using the *Ten Item Personality Inventory* (TIPI; Gosling et al., 2003). The TIPI measures Big Five personality traits, which are neurobiologically rooted, general personal predispositions or tendencies towards certain affective, behavioural and social perceptions, interpretations and responses (see McCrae & Costa Jr., 2008). These traits tend to remain more stable over longer time periods, and reciprocally influence state-level experiences. Existing research indicates inconsistencies in the pattern and strength of associations between mindfulness and Big Five traits (Haliwa et al., 2021) – thus the inclusion

of the TIPI in the present study. The TIPI presented participants with instructions and a prompt that says “I see myself as:” followed by ten different statements each representing one of the Big Five traits of *openness* (e.g., “Open to new experiences, complex.”; “Conventional, uncreative.”); *conscientiousness* (e.g., “”Dependable, self-disciplined.”; “Disorganized, careless.”); *extraversion* (e.g., “Extraverted, enthusiastic.”; “Reserved, quiet”); *agreeableness* (e.g., “Critical, quarrelsome.”; “Sympathetic, warm.”); and *emotional stability* (e.g., “Anxious, easily upset.”; “Calm, emotionally stable.”). Subjects were asked to rank their agreement with the presented statements on a Likert-style scale ranging from 1 (“Disagree strongly”) to 7 (“Agree strongly”), and negatively-toned items were reverse-scored.

Individual Differences: State and Trait Mindfulness. State mindfulness was measured using the *State Mindfulness Scale* (SMS; Tanay & Berenstein, 2013). The SMS measures present-moment awareness of subjective cognitive experience and bodily sensations during a particular episodic experience – in this case, during performance of the cognitive test battery. This offers a measure of the subjects’ level of perceived mindfulness while performing the assigned tasks. Subjects received the instruction: “Below is a list of statements. Please use the rating scale to indicate how well each statement describes your experiences in the past 15 minutes.” They were then presented with statements to gauge their mindfulness levels during the previous testing segments (e.g., “I noticed physical sensations come and go.”; “I was aware of different emotions that arose in me.”). Subjects responded on a five-point Likert-style scale ranging from 1 (“not at all”) to 5 (“very well”) in accordance with how they felt during the tasks performed immediately prior.

Trait (dispositional) mindfulness was measured using the *Five Factor Mindfulness Questionnaire – Short Form* (FFMQ-SF; Bohlmeijer et al., 2011), which is a survey of innate personal predispositions towards mindful attitudes and behaviors. In other words, the FFMQ-SF measured subjects’ general tendency to stay open, aware, attentive, non-judgmental, and non-reactive to present-moment experience, both internal and external. Subjects responded to

statements regarding mindful tendencies across 5 dimensions: observing (e.g., “I pay attention to physical experiences, such as the wind in my hair or sun in my face.”); describing (e.g., “I'm good at finding words to describe my feelings.”); acting with awareness (e.g., “I find it difficult to stay focused on what's happening in the present moment.”); nonjudging (e.g., “I make judgments about whether my thoughts are good or bad.”); and nonreacting (e.g., “I watch my feelings without getting carried away by them.”). Subjects respond using a five-point Likert-style scale ranging from 1 (“never or very rarely true”) to 5 (“very often or always true”); their selection represents the degree to which they believe the statement applies to them, in general.

Individual Differences: State and Trait Metacognition. State metacognition was measured using the *State Metacognitive Inventory* (SMI; O’Neil and Abedi, 1996) – specifically, five questions from the *Awareness* subscale of this inventory, which was most relevant for our purposes. Participants responded to one of several statements about their perceptions and experience during the task they just completed (i.e., the test battery), for example: “I was aware of my ongoing thinking processes.”; “I was aware of which thinking technique or strategy to use and when to use it.” Participants were asked to rank how they felt during the testing they just completed; subjects responded on a 4-point Likert-style scale ranging from 1 (“Not at all”) to 4 (“Very much so”).

Trait (dispositional) metacognition was measured using the *Metacognition Self-Assessment Scale* (MSAS; Pedone et al., 2017). Subjects responded to statements that quantify various aspects of metacognitive ability, including monitoring (e.g., “I am aware of what are the thoughts or emotions that lead to my actions.”); differentiation (e.g., “I am aware that what I think about myself is an idea and not necessarily true. I realize that my opinions may not be accurate and may change.”); integration (e.g., “I can describe the thread that binds my thoughts and my emotions even when they differ from one moment to the next.”); decentration (e.g., “I am aware that others may perceive facts and events in a different way from me and interpret them differently.”); and mastery (e.g., “I can deal with the problems trying to challenge

or enrich my views and my beliefs on problems themselves."). Statements are self-, other-, and problem-oriented in focus. Subjects responded on a five-point Likert-style scale ranging from 1 ("never") to 5 ("almost always") corresponding to the degree they feel the statement represents them in general.

Socio-Affective Functioning: Anxiety. Both state and trait anxiety were assessed using the STAIS5 & STAIT5, respectively, which are adapted short-form 5-item versions of the original *State-Trait Anxiety Inventory* (STAI; Marteau & Bekker, 1992). The STAIS5 and STAIT5 both involve response from subjects on a 4-point Likert-style scale ranging from 1 ("not at all") to 4 ("very much so"). For the STAIS, subjects were presented with 5 brief statements ("I feel upset"; "I feel frightened"; "I feel nervous"; "I feel jittery"; "I feel confused") and asked to indicate on the scale how the presented statement describes what they were feeling in the present moment.

Similarly, the STAIT5 presented 5 more general statements about how people describe themselves (e.g. "I feel that difficulties are piling up so that I cannot overcome them; I worry too much over something that really doesn't matter"), and asked subjects to rate how much the presented statement applies to them in general along the same 4-item rating scale.

Socio-Affective Functioning: Depression. Depression was measured using the *9-item Patient Health Questionnaire* (PHQ-9; Kroenke & Spitzer, 2002), which is a common clinical diagnostic and research tool used to assess presence and severity of recent depressive symptoms. Subjects were presented with a range of statements naming depressive problems (e.g., "Little interest or pleasure in doing things"; "Feeling down, depressed or hopeless") and were asked to rate how much they have been bothered by the listed problems over the last two weeks. Subjects responded on a 4-item scale ranging from 0 ("not at all") to 3 ("nearly every day"). Further, subjects were prompted: "If you checked off any problems, how difficult have these problems made it for you to do your work, take care of things at home, or get along with

other people?" Again, a 4-item scale was used for subjects' responses – this time ranging from 0 ("not difficult at all") to 3 ("extremely difficult").

Socio-Affective Functioning: Stress. Trait-level stress was measured using the *10-item Perceived Stress Scale* (PSS-10; Cohen & Williamson, 1988). This measure used a 5-item Likert-style rating from 0 ("never") to 4 ("very often") to measure trait-level stress (i.e. stress over an extended period of time – in this case, the past month). Subjects were given 10 questions asking about their feelings and thoughts during the last month (e.g., "In the last month, how often have you been upset by something that happened unexpectedly?"; "In the last month, how often have you felt nervous and stressed?"). Subjects indicated how often they felt the way described by each question.

Additionally, state-level stress was measured using a daily prompt which was part of the post-mindfulness practice session daily wrap-up in the online intervention module (see Procedure section for more details). Subjects were asked to provide simple feedback after their daily mindfulness practice session was complete. To measure state stress specifically, one of the prompts presented was "Please rank how relaxed you presently feel." and subjects responded on a Likert-style scale from 1 ("not at all") to 5 ("extremely"). Importantly, this relaxation item was then reverse-scored to provide a measure of subjective state-level stress.

Mindfulness-Based Intervention (Experimental Group)

The experimental group received an adapted version of a standardized mindfulness-based intervention created by Isbel and Summers (2017). Our MBI (see **Appendix I**) adopted the standardized instructions from the Isbel and Summers (2017) protocol but reduced the daily practice requirements to 15 minutes. Moreover, the intervention was administered entirely online via a specialized web module specially developed for our purposes. Thus, no in-person class or instruction elements were part of this adapted MBI; however, one principal researcher (JSHT) is an experienced mindfulness practitioner with thousands of hours practiced over approximately 15 years, who is knowledgeable about both mindfulness protocols and the

broader scientific mindfulness literature. This principal researcher was actively involved in answering any participant questions about the practice requirements and methods – and daily participant feedback and questions were solicited through the online web module (see Procedure section). This method of interaction with participants served to minimally simulate some the in-person elements originally recommended by Isbel and Summers (2017) – though this notably reduced the social interaction for the intervention.

Our adapted MBI involved listening daily to a pre-recorded 15-minute audio file which contained a reading by the principal researcher of the meditation instructions, paired with approximately 4 minutes of silence. Importantly, the audio file presented to MBI participants was the exact same file presented each day (i.e. MBI subjects heard the exact same audio content daily). This auditorily guided mindfulness meditation served to train participants on the mindfulness practice technique through repetition of key instructions and offered them silence to briefly practice and consolidate the instructions into memory. Subjects were further encouraged (but not required) to practice as often as they wished.

Podcast Intervention (Active Control Group)

The active control group for this study listened daily to a 15-minute segment from one of four educational podcast episodes discussing neuroscientific tools for health and wellbeing. Four episodes from Dr. Andrew Huberman's publicly available "Huberman Lab" podcast (Episode #95, about learning and speaking languages; Episode #87, about the neuroscience of speech, language and music; Episode #86, about what alcohol does to your brain, body and health; and Episode #85, about exercise, nutrition, and hormones; see https://hubermanlab.com/ for more information) were cut up into 15-minute chunks and presented each day in sequence over the duration of the 31-day intervention period. Thus, in contrast to the MBI group, the podcast group heard slightly different but related audio files each day (rather than the exact same file repeated daily). The same daily feedback

prompts/questions presented to the MBI group were also solicited from participants after each podcast session, for the sake of continuity and interactivity with subjects.

Procedure

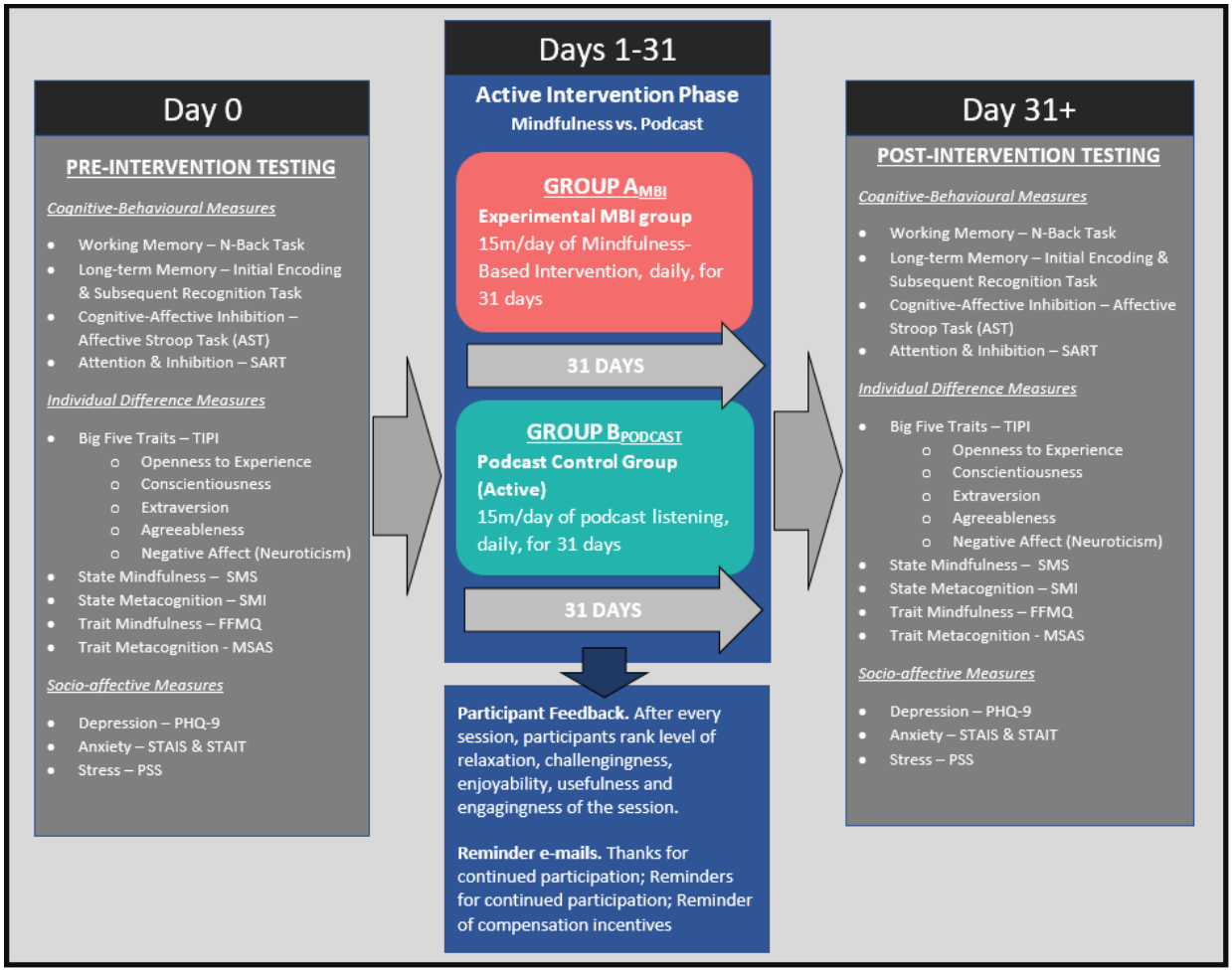
All participants were initially screened by a principal researcher (either in-person or via Zoom) to ensure they met eligibility criteria (i.e. meditation-naïve). In addition, all participants had an approximately 10-minute meeting with the same principal researcher, during which a script of a study outline was read to subjects, and it was stressed that ongoing participation was needed for this study. This was to ensure subjects had social accountability to the researcher via explicit request from the researcher to maintain ongoing participation, thus helping to increase retention rates and decrease participant turnover.

Prior to initiating their first daily session (either mindfulness or podcast), participants were required to complete the initial set of pre-intervention cognitive testing and questionnaires online at home (see **Figure 1**). This testing was administered online so that subjects could complete it in the comfort of whatever environment they chose. At no time were participants brought into the lab for testing nor intervention sessions. Participants were requested to complete the testing session in an area where they could focus on the tasks at hand. From start to finish the testing took approximately 45 minutes to complete – about 30 minutes of cognitive testing, followed by presentation of the socio-affective and individual difference measure questions and prompts. The cognitive tasks were pseudo-randomized (except for the LTM task, for which LTM encoding was always first and LTM recognition was always last). The socio-affective and individual difference measure questionnaires were randomized. Age and gender information was also solicited. Post-intervention testing was identical to the initial pre-intervention testing.

Subjects were first presented with the LTM encoding phase word list and asked to try to remember the words for later. Next, subjects were presented with the WM (N-back), EI (affective Stroop Task and SART), and attention (SART) in pseudo-randomized order. Finally,

Figure 1

Experiment Visual Flow Chart



Note. Prior to beginning their daily online mindfulness-based intervention (MBI), subjects completed an initial battery of pre-intervention testing (session one) which included cognitive-behavioural, socio-affective, and individual difference measures. From days 1 to 31, subjects completed their daily online session and post-session feedback. After their final session on the 31st day, subjects proceeded to complete the post-intervention testing session (session two), which was identical to session one.

participants were presented with the word list for the recognition phase of the LTM task and asked to indicate which words they recognized from the initial encoding set. Once this was complete, subjects were then presented with the socio-affective and individual difference self-report questionnaires in randomized order. Upon completion of the final questionnaire, the data was submitted automatically to our server. Once initial pre-intervention testing was completed, participants began their first assigned daily session. From then on, subjects were expected to complete one session daily – ideally each day, for a total of 31 days. Understanding that ideal (full) compliance was not most likely, we set the minimum required number of sessions for full participation to 12 sessions, which is equivalent to approximately 3 sessions per week.

After each individual daily session, subjects were prompted to share feedback for five fixed-response questions and two open-ended subjective experience questions about their session and how they presently feel. Participants were asked to complete post-session feedback consisting of five fixed-choice rank-style prompts for various experiential dimensions: relaxation (“Please rank how relaxed you presently feel”); challenging (“Rank how challenging you found the intervention”); engaging (“Rank how engaging you found the intervention”); usefulness (“Rank how useful you found the intervention”); and enjoyability (“Please rank how enjoyable you found the intervention”). Subjects were required to select a response for each prompt on a Likert-style scale between 1 (“not at all”) and 5 (“extremely”).

On the same post-session screen, subjects were also presented with two open-ended feedback prompts (“Briefly describe your favourite and least favourite aspects of this session”; and “Briefly describe your overall personal subjective experience of this session”). For these open prompts, participants were asked to provide a few sentences about their thoughts about and experience of the session they just completed.

A final feedback screen was then presented to subjects which allowed them to submit questions and comments directly to the researcher. Participants were instructed that they would receive a response to any questions or comments within 24-hours – and that response would be

generalized to all participants in the same intervention, to avoid duplication of questions and ensure participants all had equivalent information from the researcher.

Participants proceeded to complete as many daily sessions as possible over the course of the 31 days, with a minimum of one session per day being requested by researchers (*N.B.*: though most participants did not complete all 31 sessions, a minimum of 12 sessions total were completed by all subjects to be included in the analysis, equivalent to about 3 sessions per week).

After the 31-day period was over, subjects then completed the post-intervention testing, which was identical to the pre-intervention testing. Once all post-intervention test data had been submitted, payments were distributed, and subjects were debriefed about study details, protocols and purposes.

Results

Post-session Feedback Quantitative Data

While ideal performance involved 31 daily sessions, the actual number of sessions performed per participant deviated from this, as expected. The MBI (M = 18.19) and podcast (M = 19.82) groups did not significantly differ, as determined by an independent samples t-test, on number of completed sessions overall – with subjects completing about 4-5 daily sessions per week on average for both groups (for descriptive statistics, see **Table 1** and **Table 2**).

Differences between groups for the post-intervention session questions were assessed through linear mixed-effects models, given that each participant completed the same set of questions a variable number of times (related to the number of completed sessions). Separate models were created for each question, and each model contained condition as a predictor variable and also included random intercepts for participant.

Overall, analysis showed significant differences in scores between groups for two out of the five questions assessed after each intervention session: post-session relaxation level and how challenging the session was. For the post-session relaxation score (which was reverse

Table 1

Raw Scores for Cognitive, Socio-Affective, and Individual Difference Tasks or Measures

		MBI Group		Podcast Group		
	Measure	Testing Session 1	Testing Session 2	Testing Session 1	Testing Session 2	Significance (C/S/C*S/ns)
Cognitive Task Performance						
	WM (N-back)	16.04	19.90	19.54	23.94	S
	LTM (Recognition)	10.91	11.52	11.08	13.25	*n.s.*
	EI (Affective Stroop Task)	14.55	32.28	18.00	39.50	S * Valence
	Attention & Inhibition (SART)	11.83	9.90	10.12	8.38	*n.s.*
Socio-Affective Functioning						
	Depression (PHQ-9)	10.78	8.47	12.42	8.13	S
	State Anxiety (STAIS)	.70	.38	.63	.55	*n.s.**
	Trait Anxiety (STAIT)	1.62	1.48	1.58	1.24	S
	Trait Stress (PSS)	21.00	17.52	21.92	18.19	S
Individual Differences						
	State Mindfulness (SMS)	65.65	76.52	67.67	64.31	C*S
	Trait Mindfulness (FFMQ-SF)	14.83	16.03	15.26	15.09	C*S
	State Metacognition (SMI)	2.01	2.21	2.04	1.90	*n.s.**
	Trait Metacognition (MSAS)	68.00	72.14	67.92	71.50	S
Big Five Trait Scores						
	Openness	5.38	5.09	5.28	5.06	*n.s.**
	Conscientiousness	5.52	5.60	4.97	5.34	*n.s.*
	Extraversion	3.98	3.95	3.94	3.91	*n.s.*
	Agreeableness	4.48	4.79	4.72	4.97	*n.s.**
	Emotional Stability	4.36	4.43	4.34	4.53	*n.s.*

Note. * = marginal result, did not meet but approached alpha of .05. C = Condition main effect; S = Session main effect; C*S = Condition x session interaction effect; *n.s.* = not significant; S * Valence = Session x valence interaction effect, unique to the Stroop task.

Table 2

Raw Average Scores for Feedback Provided after Each Daily Intervention Session

Measure	Daily Post-Intervention Session Rank Scores		
	MBI Group Average	Podcast Group Average	Significance (C/S/C*S/ns)
Relaxing	3.75	3.39	C(MBI)
Challenging	2.87	2.45	C(MBI)
Engaging	3.17	3.05	*n.s.*
Useful	3.45	3.07	*n.s.**
Enjoyable	3.42	3.12	*n.s.**

Note. * = marginal result, did not meet but approached alpha of .05. C = Condition main effect; S = Session main effect; C*S = Condition x session interaction effect; *n.s.* = not significant; S * Valence = Session x valence interaction effect, unique to the Stroop task.

scored to represent a state stress measure) participants in the MBI group (*M* = 3.75) reported significantly higher levels of post-session relaxation (and thus lower stress) immediately post-session relative to the podcast group (*M* = 3.39), *t*(41.98) = –2.30, *p* = .026 (**Figure 2a**). For the ranking of how challenging the just-completed session was, participants in the MBI group (*M* = 2.87) reported that the session was significantly more challenging than the podcast (*M* = 2.45), *t*(40.74) = –2.15, *p* = .038 (**Figure 2b**). Thus, MBI participants found their intervention significantly more challenging than the podcast participants.

In contrast, enjoyability, engagingness, and usefulness saw no meaningfully significant differences in rankings between intervention groups at our alpha value. Moreover, an overall composite score (mean average) of all the post-session feedback variables showed that the mindfulness group's subjective perceptions of the sessions was significantly more positively influenced than the podcast group, *t*(42.70) = -2.08, *p* = .044).

Cognitive, Socio-Affective, and Individual Difference Data

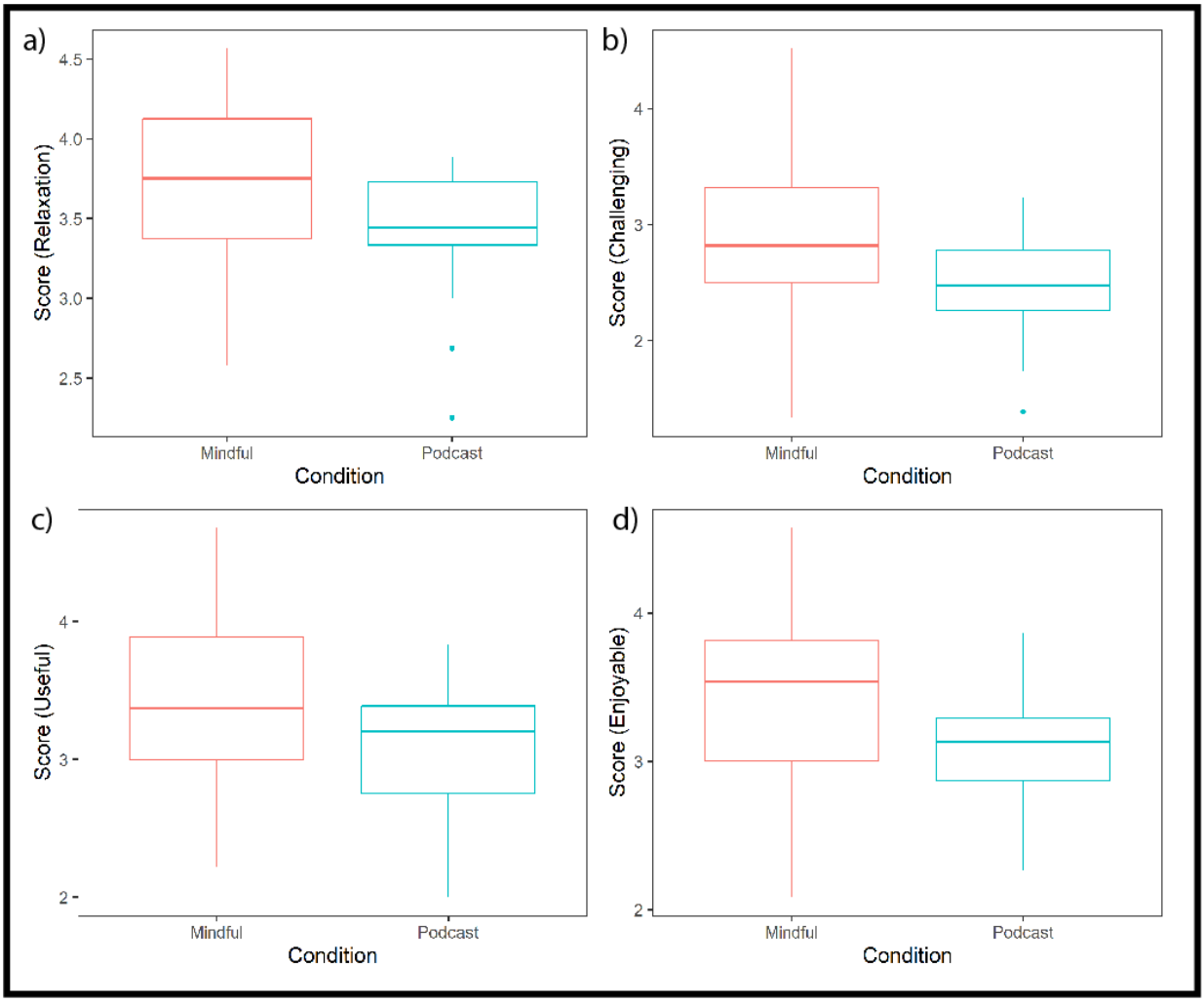
A series of 2 (Condition: Mindfulness-Based Intervention (MBI) vs. Podcast) by 2 (Session: Pre-Intervention Testing Session 1 (Test Session 1) vs. Post-Intervention Testing Session 2 (Test Session 2)) mixed analyses of variance (ANOVAs) were conducted to explore possible influences of each intervention on participants' cognitive performance, socio-affective functioning, and individual difference (state- and trait-level) factor scores. We tested for possible interaction effects between condition (between-subjects) and session (within-subjects) to determine whether the mindfulness intervention had a significant effect on performance and individual differences relative to the podcast control group. We thus also tested main effects of condition and session, respectively. Groups were well matched across all dimensions, with no significant differences at baseline for any of the measured factors (see **Table 3**).

Cognitive Functioning

Long-Term Memory – Word Recognition Task. The 2 (Condition: MBI vs. Podcast) by 2 (Session: Test Session 1 vs. Test Session 2) mixed ANOVA showed no significant effects on

Figure 2

Post-Intervention Session Feedback Data



Note. Participants in the MBI group found their mindfulness intervention sessions significantly more relaxing (a) and challenging (b) than the podcast group did. Additionally, they found the mindfulness intervention marginally more useful (c) and enjoyable (d) than the podcast group.

Table 3

Equivalence of Both Groups at Testing Session 1 on All Variables of Interest

Factor	MBI Group at Testing Session 1	Podcast Group at Testing Session 1	Between-Group Comparison
Age	*M* = 21.24, *SD* = 6.50	*M* = 22.25, *SD* = 6.83	*n.s.*
Gender	71.4% F, 28.6% M, 0% Non-Binary	81.2% F, 6.3% M, 12.5% Non-Binary	*n.s.*
Cognitive Performance Measures			
Cognitive Task	MBI Group at Testing Session 1	Podcast Group at Testing Session 1	Between-Group Comparison
LTM Task[1]	10.91	11.08	*n.s.*
WM (N-Back) Task[2]	16.04	19.54	*n.s.*
Inhibition (affective Stroop) Task[3]	*14.55*	18.00	*n.s.*
Attention (SART) Task[4]	11.83	9.90	*n.s.*
Socio-Affective Measures			
Socio-Affective (Mood) Factor	MBI Group at Testing Session 1	Podcast Group at Testing Session 1	Between-Group Comparison
Depression - PHQ-9	10.78	12.42	*n.s.*
Trait Anxiety - STAIT	1.62	1.58	*n.s.*
State Anxiety - STAIS	0.695	0.625	*n.s.*
Trait Stress - PSS	21.00	21.92	*n.s.*
Individual Difference Measures			
Dispositional Mindfulness (FFMQ Subscales)	MBI Group at Testing Session 1	Podcast Group at Testing Session 1	Between-Group Comparison
Observing	14.05	13.63	*n.s.*
Acting with Awareness	16.24	15.43	*n.s.*
Describing	16.57	16.81	*n.s.*
Nonjudgment	14.05	15.94	*n.s.*
Nonreactivity	13.90	14.44	*n.s.*
Trait Metacognition (MSAS Subscales)	MBI Group at Testing Session 1	Podcast Group at Testing Session 1	Between-Group Comparison
Decentration	12.81	13.00	*n.s.*
Differentiation	7.33	7.44	*n.s.*
Integration	6.95	6.50	*n.s.*
Mastery	18.19	18.13	*n.s.*
Monitoring	23.57	24.00	*n.s.*

Big Five Personality Trait Factors (TIPI)	MBI Group at Testing Session 1	Podcast Group at Testing Session 1	Between-Group Comparison
Openness	5.38	5.28	*n.s.*
Conscientiousness	5.52	4.97	*n.s.*
Extraversion	3.98	3.94	*n.s.*
Agreeableness	4.48	4.72	*n.s.*
Emotional Stability	4.36	4.34	*n.s.*

Note. All between-group equivalence comparisons were conducted using a Welch Two-Sample t-test to identify possible significant differences between experimental and control condition groups at testing session 1. [1] Words correctly recalled. [2] Accuracy (Hits – False Alarms) [3] Negative minus neutral word RT. [4] Number of commission errors.

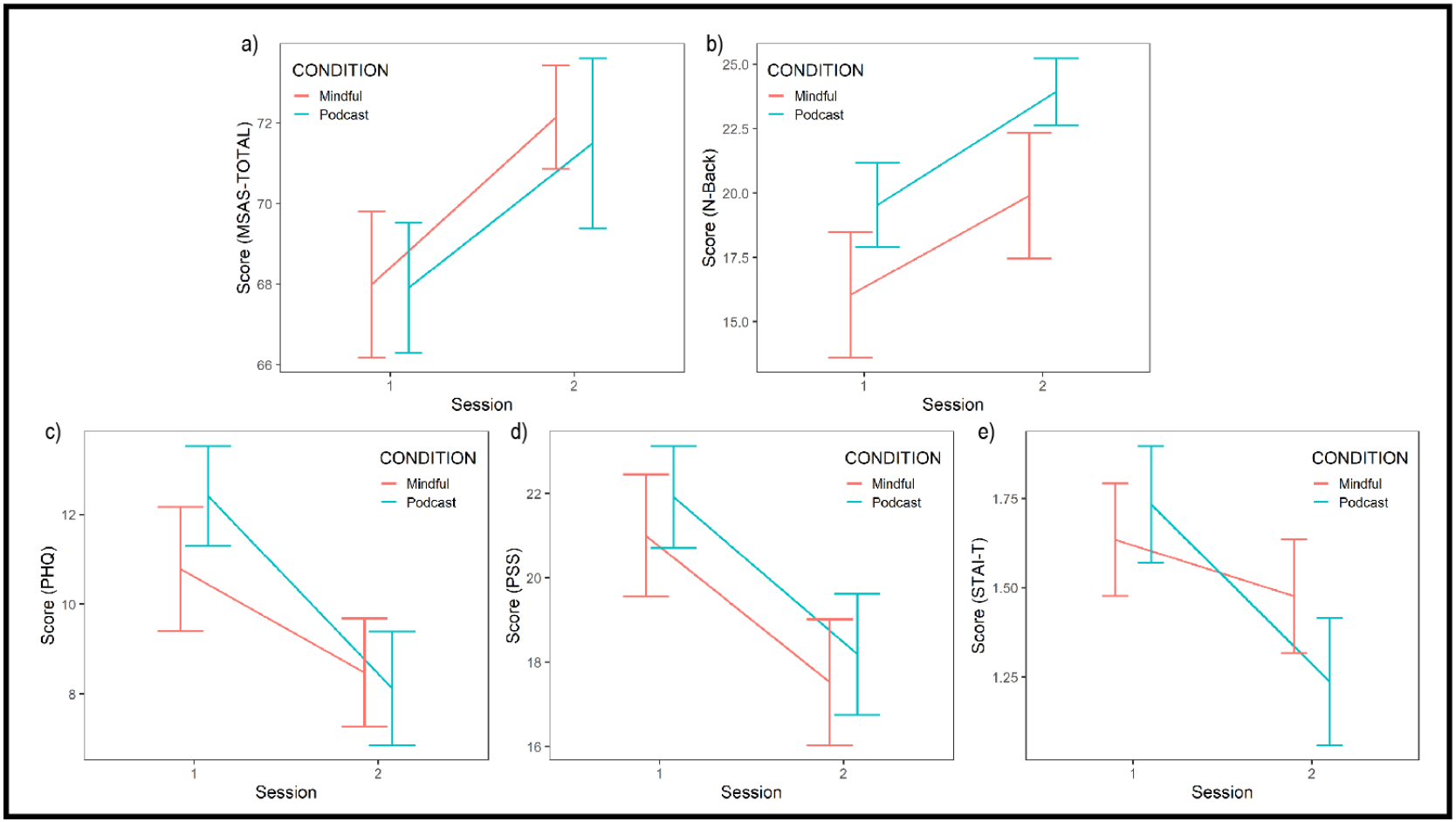
LTM performance, specifically recognition memory on our chosen LTM task (all *p*s > .05). The podcast group showed a nominal improvement in long-term memory performance (Session 1: *M* = 11.08, *SD* = 8.13; Session 2: *M* = 13.25, *SD* = 8.71), as did the mindfulness group (Session 1: *M* = 10.91, *SD* = 6.11; Session 2: *M* = 11.52, *SD* = 7.63). It is noteworthy that a series of one sample t-tests against a known mean of zero confirmed that, for each session, both groups were robustly above chance (all *p*s < .001), suggesting that participants understood the task and performed it correctly.

Working Memory – N-Back Task. The 2 (Condition: MBI vs. Podcast) by 2 (Session: Test Session 1 vs. Test Session 2) mixed ANOVA found a significant main effect of session, $F(1, 35) = 9.77$, $p = .004$. Regardless of intervention condition, participants significantly improved from the pre-intervention testing session to the post-intervention testing session (overall, Session 1: *M* = 17.83, *SD* = 10.50; Session 2: *M* = 21.65, *SD* = 9.21; see **Figure 3b**). Moreover, a series of one-sample t-tests against a known mean of zero showed that, for each session, both groups were independently above chance performance on the task (all *p*s < .001) – suggesting participants understood and performed the task well.

Executive Inhibition & Attention – Stroop, SART. For the affective Stroop task, a 2 (Condition: MBI vs. Podcast) by 2 (Session: Test Session 1 vs. Test Session 2) x 2 (Stroop word valence: neutral vs negative) mixed ANOVA revealed a significant effect of valence ($F(1, 35) = 10.97$, $p = .002$), with negatively valenced words leading to significantly longer response times (*M* = 776 ms, *SD* = 178 ms) compared to neutral words (*M* = 752 ms, *SD* = 164 ms), as predicted. Further, we also found a significant session-by-valence interaction, $F(1, 35) = 4.74$, $p = .036$, which can be characterized by an *increase* in the magnitude of the response time detriment for negatively valenced words in the second testing session (difference between negative vs neutral word response time: Session 1: 16 ms difference; Session 2: 35 ms).

Figure 3

MBI and Podcast Groups Increased on Working Memory and Trait Metacognition, and Decreased in, Depression, Trait Anxiety, and Trait Stress



Note. Overall, both the podcast and mindfulness groups saw equivalent improvement on several factors, including (a) increased trait metacognition, (b) improved working memory, (c) reduced depression symptoms, (d) reduced stress in general, and (e) reduced anxiety in general.

For the SART, no significant effects were found with respect to session or condition (all *p*s > .05) on attentional performance. That is, no difference in performance between groups or from test one to test two were found.

Depression, Stress, and Anxiety

Depression. For PHQ-9 depression scores, the 2 (Condition: MBI vs. Podcast) by 2 (Session: Test Session 1 vs. Test Session 2) mixed ANOVA showed a significant main effect of session on depression, $F(1,35) = 5.39$, $p = .026$, such that overall there was a significant reduction in depression scores (Session 1: $M = 11.62$, $SD = 6.04$; Session 2: $M = 8.32$, $SD = 5.27$), with no significant difference between conditions either in terms of a main effect or in terms of a condition-by-session interaction. In other words, both groups decreased in depressive symptoms (see **Figure 3c**).

Trait Stress. For trait-level stress, the 2 (Condition: MBI vs. Podcast) by 2 (Session: Test Session 1 vs. Test Session 2) mixed ANOVA showed a significant main effect of session, $F(1,35) = 10.22$, $p = .003$. PSS-10 scores for both groups decreased from session 1 ($M = 21.47$, $SD = 6.39$) to session 2 ($M = 17.81$, $SD = 6.30$) representing an improvement in stress scores across both groups (see **Figure 3d**).

State Anxiety. The 2 (Condition: MBI vs. Podcast) by 2 (Session: Test Session 1 vs. Test Session 2) mixed ANOVA for the STAI-S scores showed no significant effect of either intervention on state-level anxiety – though the condition x session interaction approached marginal significance in the expected direction, $F(1,35) = 2.77$, $p = .105$. That is, the mindfulness group saw nominally larger reductions in state-level anxiety scores (Session 1: .67; Session 2: .38) compared to the podcast control group (Session 1: .51; Session 2: .55), with paired samples t-tests showing that the reduction in the MBI group was significant, $t(20) = 2.66$, $p = .015$, whereas the reduction in the podcast control group was not, $t(15) = -0.22$, $p = .831$). However, such results cannot be meaningfully interpreted given the lack of overall statistical significance from the interaction term.

Trait Anxiety. The 2 (Condition: MBI vs. Podcast) by 2 (Session: Test Session 1 vs. Test Session 2) mixed ANOVA for the STAI-T showed a significant main effect of session, $F(1,35) = 4.17$, $p = .049$. This main effect was characterized by a reduction in dispositional anxiety overall from session 1 to session 2 across both groups (see **Figure 3e**).

Individual Difference Factors

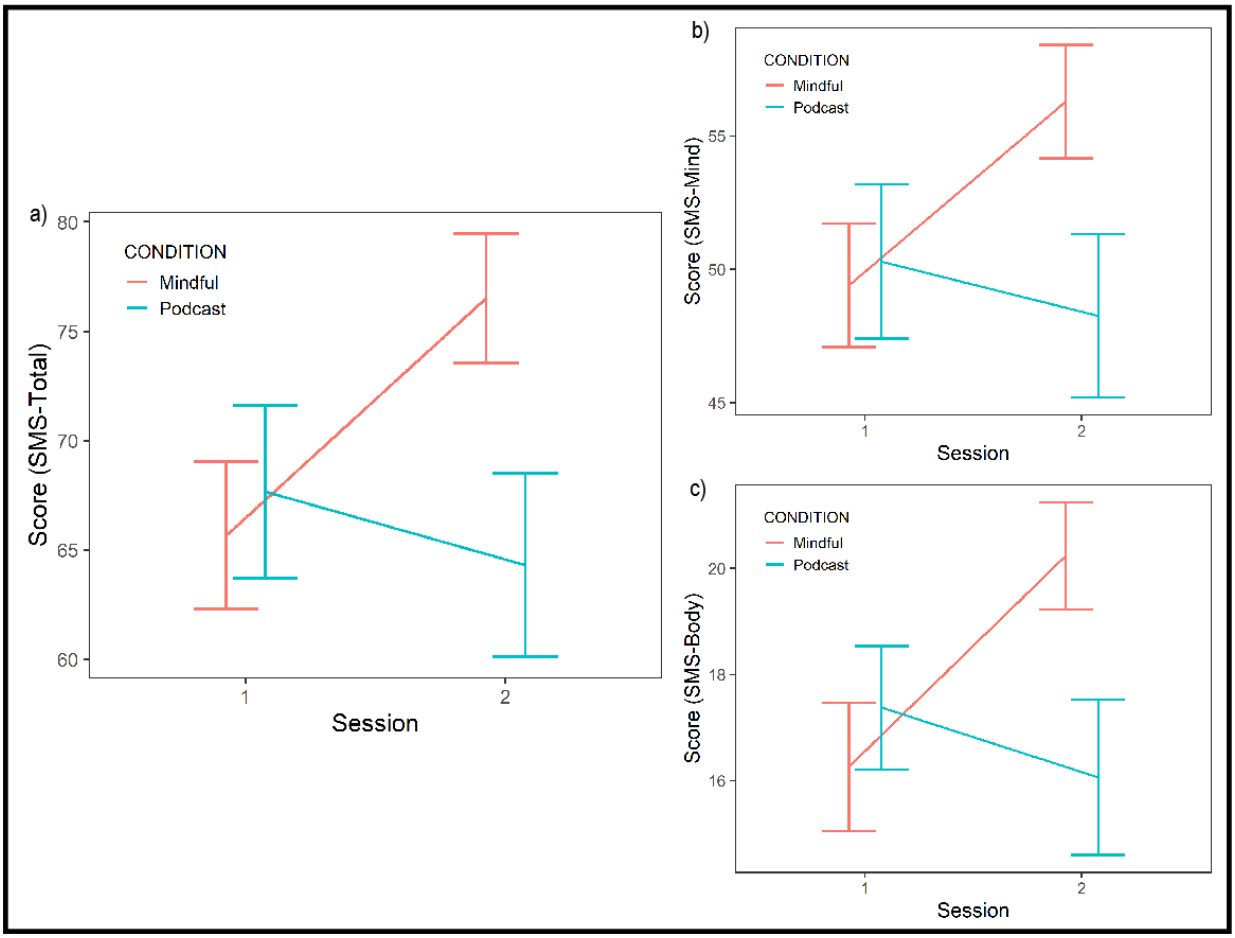
State Mindfulness. For the overall state mindfulness score, the 2 (Condition: MBI vs. Podcast) by 2 (Session: Test Session 1 vs. Test Session 2) mixed ANOVA revealed a significant condition-by-session interaction, $F(1,35) = 8.12$, $p = .007$ (see **Figure 4a**). Both the *Body* ($F(1,35) = 10.80$ $p = .002$; **Figure 4b**) and *Mind* ($F(1,35) = 5.27$ $p = .028$; **Figure 4c**) subscales were also significant. Importantly, all interaction effects were in the expected direction. The mindfulness condition (Session 1: $M = 65.65$; Session 2: $M = 76.52$) saw significantly greater improvements in state mindfulness from pre- to post-intervention testing, relative to the podcast condition (Session 1: $M = 67.67$; Session 2: $M = 64.31$), which nominally decreased in mindfulness overall.

Dispositional (Trait) Mindfulness. Overall, for total dispositional mindfulness scores on the FFMQ, the 2 (Condition: MBI vs. Podcast) by 2 (Session: Test Session 1 vs. Test Session 2) mixed ANOVA revealed a significant condition-by-session interaction effect, $F(1,35) = 4.22$, $p = .047$. In other words, the MBI group uniquely improved overall on dispositional mindfulness relative to the podcast group which saw no such improvement – and actually decreased slightly overall in dispositional mindfulness (see **Figure 5a**).

More specifically, the ANOVA revealed on the *Observe* subscale of the FFMQ a significant condition-by-session interaction in our expected direction, $F(1,35) = 8.57$, $p = .006$; subjects in the mindfulness condition improved significantly on this subscale from session one to session two relative to the podcast participants (see **Figure 5b**). Moreover, the ANOVA for the *Nonreactivity* subscale of the FFMQ also revealed a significant main effect of session, $F(1,35) = 4.97$, $p = .032$. However, this effect appeared to be driven entirely by the MBI group

Figure 4

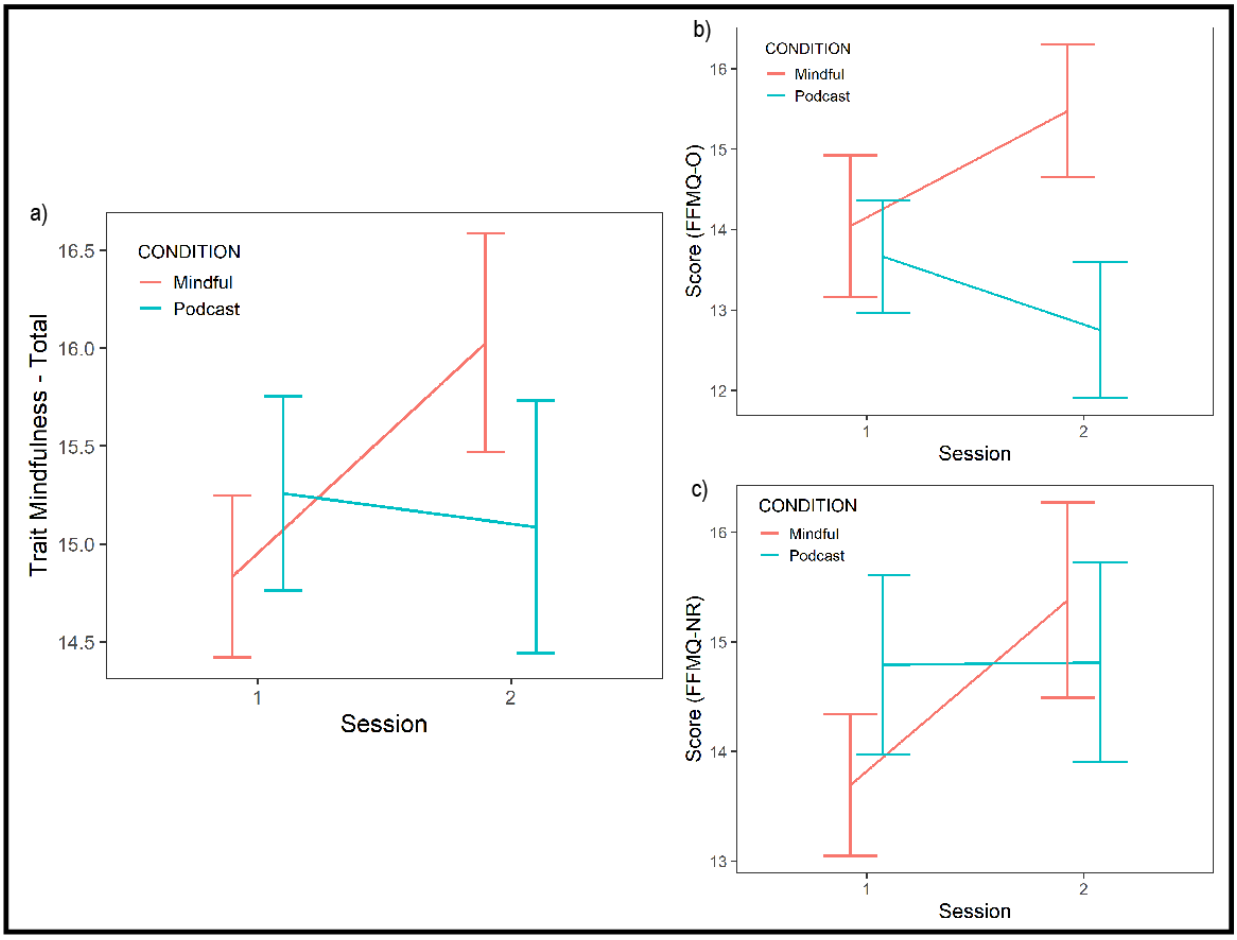
MBI Group's Unique Improvements in State-Level Mindfulness (SMS)



Note. The MBI group showed unique improvements to state-level mindfulness during the cognitive testing and personal questionnaire tasks, reflected by increased SMS scores overall (a) – and on both the mind (b) and body (c) subscales. Increases in state mindfulness were observed for the MBI group but not the podcast group.

Figure 5

MBI Group Unique Improvements in Dispositional Mindfulness (FFMQ)



Note. The MBI group showed unique improvements to dispositional (trait) mindfulness overall (a) on the FFMQ. Increased scores on the *Observance* (b) and *Nonreactivity* (c) subscales of the FFMQ were observed that were unique to the MBI group.

(see **Figure 5c**). Thus, nonreactivity decreased from session one to session two overall, which was driven entirely by increases in the MBI group; mindfulness participants considerably increased in nonreactivity (became less reactive), while the podcast group was virtually flat.

ANOVAs for the *Acting with Awareness, Non-judgment,* and *Describe* subscales revealed no significant effects of either intervention on trait mindfulness for these subscales. Test-retest reliability was relatively high across sessions, lending credence to good internal validity of results (across all individual difference factors - see **Table 4**).

State Metacognition. State metacognition was measured using the *Awareness* subscale of the SMI. The 2 (Condition: MBI vs. Podcast) by 2 (Session: Test Session 1 vs. Test Session 2) mixed ANOVA showed a marginal interaction approaching significance in the expected direction, $F(1,35) = 3.09$, $p = .088$. The mindfulness condition (Session 1: $M = 2.00$; Session 2: $M = 2.21$) saw slightly improved metacognition scores compared to the podcast condition (Session 1: $M = 2.04$; Session 2: $M = 1.90$). Given *a priori* predictions that state metacognitive scores would increase in the mindfulness but not control condition, follow-up t-tests to unpack this marginal interaction showed that the improvement in the mindfulness condition was marginally significant, $t(20) = -1.74$, $p = .096$, whereas the change in the podcast condition was not significant, $t(15) = 0.87$, $p = .396$.

Trait Metacognition. For trait metacognition, overall, the 2 (Condition: MBI vs. Podcast) by 2 (Session: Test Session 1 vs. Test Session 2) mixed ANOVAs showed a total significant main effect of session on trait metacognition, $F(1,35) = 7.90$, $p = .008$. Moreover, effect significance varied by subscale; significant effects were found on the *Differentiation* ($F(1,35) = 6.62$, $p = .015$), *Integration* ($F(1,35) = 7.80$, $p = .008$), and *Mastery* ($F(1,35) = 6.40$, $p = .016$) subscales, whereas for the *Decentration* and *Monitoring* subscales, no significant effects were found. In other words, both groups showed overall improvements in trait metacognition from the pre-intervention session to the post-intervention session (see **Figure 3a**).

Table 4

Test-Retest Reliability Across Sessions for Individual Differences

Mindfulness	
Dispositional Mindfulness (FFMQ-SF)	Test-retest reliability
Observe	*r* = .77
Describe	*r* = .72
Acting With Awareness	*r* = .59
Nonjudging	*r* = .56
Nonreacting	*r* = .77
Metacognition	
Trait Metacognition (MSAS)	Test-retest reliability
Decentration	*r* = .50
Differentiation	*r* = .01
Integration	*r* = .72
Mastery	*r* = .56
Monitoring	*r* = .62
Total	*r* = .68
Big Five Factors	
Trait Factor	Test-retest reliability
Openness	*r* = .74
Conscientiousness	*r* = .74
Extraversion	*r* = .88
Agreeableness	*r* = .73
Emotional Stability	*r* = .80

Note. On average, test-retest reliability was consistent across testing sessions for the individual difference factors overall, with some variance within sub-facets of higher-order factors.

Big Five Personality Inventory. The 2 (Condition: MBI vs. Podcast) by 2 (Session: Test Session 1 vs. Test Session 2) mixed ANOVAs for the Big Five individual difference factors revealed marginal main effects of session on both *Openness* ($F(1,35) = 3.08$, $p = .088$) and *Agreeableness* ($F(1,35) = 3.79$, $p = .060$) , indicating possible marginal changes on these two personality dimensions (decreased openness, increased agreeableness) for both groups from session one to two. No significant effects were found for *Conscientiousness*, *Extraversion*, and *Emotional Stability*. Test-retest reliability for these items indicated high reliability of trait results from session one to two, and groups were equally matched across all Big Five dimensions pre-intervention.

Mindfulness and Metacognition: Related Yet Distinct

To address our research question of how mindfulness and metacognition are distinct (but related) constructs, we ran correlational analyses (linear modeling) between all five subscales of the FFMQ-SF (mindfulness) and MSAS (metacognition). Correlations between mindfulness and metacognition were considerable and robust – and the nature and strength of the relationships between facets of each construct changed (generally increased) from testing session one to two. Correlations between mindfulness and metacognition scores at session one ($n = 47$, $r = .29$) and session two ($n = 37$, $r = .33$) generally increased from session one to session two. Thus, the correlations between mindfulness and metacognition were considerable, suggesting both cognitive faculties were mutually changed and share significant statistical overlap, and both are indeed distinct cognitive constructs.

Discussion

Our results offer preliminary support for the efficacy of our adapted 31-day, 15-minute daily mindfulness intervention in several key ways which align with prior research. We observed diverse and robust effects for several variables; some interesting marginal effects which are worthy of (cautious) further exploration; and null results which are somewhat surprising and further help elucidate what mechanisms might be at play with our MBI. The results also help to

highlight both the strengths and limitations of our brief online MBI, offering valuable insight for where adjustments and improvements may be made.

Unique Effects of MBI on Mindfulness & Stress (Relaxation)

Mindfulness

State-Level Mindfulness. At the state level, MBI group participants became substantially more mindful in relation to both their bodily sensations and the contents of their mind from moment-to-moment during the cognitive testing and questionnaire tasks. In contrast, the podcast group saw no such improvement. In other words, the MBI group demonstrated unique significant increases in state-level mindfulness that was *not* observed in the podcast group.

Dispositional Mindfulness (Trait Mindfulness). Subjects in the MBI group, but not the podcast group, showed an increase on the *observe* subscale of the FFMQ (trait-level measure), suggesting that the mindfulness group became more cognitively observant. Moreover, MBI participants also experienced an increase from test session one to two on the *nonreactivity* subscale – suggesting that the mindfulness intervention was effective in increasing behavioural-cognitive nonreactivity. Thus, subjects in the MBI group became more observant and nonreactive – while subjects in the podcast group saw no such improvements.

Unique Benefits of MBI on Mindfulness. Our results provide solid preliminary evidence that our 31-day, 15-minute daily online MBI uniquely improves dispositional mindfulness (DM) and state mindfulness, offering support for our hypothesis that dispositional mindfulness would uniquely improve as a function of the brief online MBI.

These unique effects on DM have many beneficial implications for the MBI group. For instance, DM has been associated with better working memory (Chiesa et al., 2011) – which could hypothetically help explain the WM increases observed in the MBI group (though we can't conclusively tell from our present design). Reductions in depression, anxiety, stress and increases in overall wellbeing have also been robustly associated with DM (e.g. Bränström et

al., 2011; Zimmaro et al., 2016) – a result partly reflected in our present results. DM has also been positively related to wellbeing and work engagement (Malinowski & Lim, 2015). In general, DM is associated with neuroprotective effects which lead to reductions in psychopathological symptoms, and improved general psychological functioning (Lal & Jayan, 2019).

DM has also been linked to improved learning. For example, a 2011 study by Kee and Liu demonstrated that higher DM was significantly related to enhanced motor learning. Henriksen et al. (2020) suggest that DM may help to improve learning by increasing creativity – creativity itself also being tightly linked with trait openness (see Kaufman et al., 2016). Moreover, DM has been shown to predict better university adjustment (Mettler et al., 2019) – and research shows that learning that incorporates mindfulness considerably benefits students relative to traditional learning (Reber, 2014). Reber (2014) also noted that students may benefit from principles of mindfulness to deal with adverse feelings – and this may in turn improve attention and learning.

Thus, considering the diverse correlated benefits of DM across a range of outcomes – and particularly on wellbeing and learning – it's especially noteworthy that our MBI group saw unique increases in DM and state mindfulness. Moreover, it's possible that students may have seen related improvements in their learning. Though academic outcomes were not measured in our present study, some participants did subjectively report improved focus and calm relative to their schoolwork, seemingly more so than the control group.

Post-Intervention Session Momentary Relaxation

Increased Relaxation Implies Decreased Stress Our brief online MBI also significantly decreased stress according to our proxy measure of immediate post-session relaxation, with increases observed in state-level (momentary) relaxation immediately following the completion a daily 15-minute mindfulness session. Thus, overall, our daily online MBI induced greater state relaxation than a 15-minute podcast segment immediately post-session. From this, we might reasonably infer that MBI participants (but not podcast participants) experienced lower state

stress relative to the podcast group, considering stress and relaxation may generally (though not always) be conceptualized as opposites along a continuum. Thus, reverse-scoring the relaxation measure to infer state-level stress seems nominally valid (e.g. see Dusek & Benson, 2009) – though importantly, state stress was not *directly* measured and thus such inferences must come with a caveat. It's more likely that our data represent the fact that the mindfulness intervention was better able to induce a state of relaxation overall compared to the podcast group – which may in turn imply decreased state stress. Future research might more explicitly measure state-level stress using an appropriate scale.

Trait Stress (PSS). Both MBI and podcast groups saw a decrease in trait stress – suggesting that mindfulness practice via our online MBI *and* listening to a health education-oriented podcast may similarly decrease predisposition to stress. PSS scores (which measure general stress over the last month) decreased for both the MBI and podcast groups alike. This makes sense when we consider that prior research has shown that psychoeducation and health education interventions can decrease stress and promote wellbeing (e.g. Ugwoke et al., 2017; Hood et al., 2021; Van Daele et al., 2012). Our chosen podcast was oriented towards self-betterment, psychoeducation, and health education explicitly. In addition, several other factors common to both interventions may have also contributed to the similarity of results – e.g., working memory (see Working Memory section below).

MBI Effects on Stress – Cautious Interpretation. Of course, it's worth noting that given the joint results on trait stress, and our indirect measure of state stress (using relaxation as a proxy), conclusions about MBI-specific effects must be tempered in our present case. Nonetheless, our results appear to be in line with prior research showing consistent decreases in stress from MBIs (Grossman et al., 2004; Chiesa & Serretti, 2009). Spijkerman et al. (2016) found good evidence for small to moderate effects of online MBIs on mental health, with the largest impact on stress (Hedge's g = 0.51). Souza et al. (2021) also showed that a brief MBI and dispositional mindfulness attenuated stress in a sample of university students. Lomas et al.

(2019) found that MBIs in the workplace considerably decreased stress and improved several other measures of psychological wellbeing.

Moreover, Tang et al. (2007) demonstrated significant reductions in salivary cortisol and other stress biomarkers after a brief MBI. Cortisol is secreted in the presence of stress. Considering the fact that cortisol inhibits neuroplasticity (Sale et al., 2008) and cognitive functioning (Lee et al., 2007; Law & Clow, 2020), together with the fact that DM has been robustly associated with stress reductions and lowered cortisol levels (Zimmaro et al., 2016; Sanada et al., 2016), it's reasonable to think that increases in mindfulness related to our MBI may be responsible for observed decreases in stress and cognitive improvements – and that this may proceed via the neural mechanism of reduced cortisol or other stress hormones. While this cannot be confirmed by our present analysis, converging evidence suggests this is plausible and may be worthy of further research.

MBI and Podcast Interventions Both Effective

Several results from our analysis clearly show overlapping effects of *both* the mindfulness and podcast interventions on our variables of interest. In other words, both the mindfulness and podcast groups saw beneficial shifts across several variables of interest, including trait mindfulness and metacognition, depression, trait anxiety and stress (as noted above), and working memory.

Working Memory

WM changes were observed across both groups; mindfulness and podcast participants both showed considerably improved performance on the N-back task – suggesting that both interventions were effective in enhancing working memory performance from session one to session two. It's possible to interpret this result in several ways. On one interpretation, it seems entirely possible that WM performance on the N-back task improved substantially for both groups – suggesting that not only was our online MBI effective in improving WM, but so was the podcast intervention.

WM is actively engaged by both interventions. Prior research shows that anxiety (Moran, 2016; Lukasik et al., 2019), stress (e.g. Mizoguchi et al., 2000; Luethi et al., 2009; c.f. Matthews & Campbell, 2009), and depression (Rose & Ebmeier, 2006; Maramis et al., 2021) can impair WM and cognition. Relatedly and conversely, WM improves as anxiety, depression, and stress decrease – which was the case in our present results. Moreover, Jopling and colleagues (2020) demonstrated that WM training (which characterizes an aspect of both interventions) resulted in attenuated biological response to stress and improvements in depression and rumination – highlighting that training specifically focused on WM can have beneficial effects on WM and mood. Several brief MBIs have also been demonstrated to have a positive impact on WM (e.g. Zeidan et al., 2010; Mrazek et al., 2013). Jha et al. (2019) suggest that mindfulness training helps protect and strengthen WM. Together, these factors may help explain WM improvement for both groups.

Alternatively, it's possible that there was some influence of practice; subjects may have improved from session one to two simply due to achieving task proficiency or becoming familiar with the task after the first session. This seems less likely, however, considering subjects only performed the task once prior to the second testing session, were familiarized each time via a practice 1-back task prior to completing the active 2-back task, and there were 31 days between testing, giving ample time for forgetting the task.

Stress, Anxiety & Depression

Improvements (decreases) in trait stress, trait anxiety, and depression were also found to be significant across both groups. Subjects in both conditions were less stressed, less anxious, and less depressed after the 31 days. On the mindfulness side, this is in line with prior research which shows clearly that brief MBIs improve stress, anxiety, and depression – both in-person (e.g. Chiesa & Serretti, 2009; Khoury et al., 2015) and online (e.g. Cavanagh, 2013; Spijkerman et al., 2016). Our adapted MBI thus worked as intended and exerted similar effects to those that have been demonstrated previously. On the podcast side, considering similar

elements of both interventions – such as psychoeducation, a focus on self-reflection, and health and science education (all of which can influence mood and cognition) – it's reasonable to think that the podcast group may have improved partly due to these factors. Alternatively, it's possible that some non-specific (i.e., more domain-general) factor – such as being engaged in a meaningful task, or even simply engaged in a task at all – helped contribute to such improvements.

Regardless of the mechanisms, the fact that both groups experienced beneficial reductions in stress, anxiety and depression was a somewhat surprising but nonetheless fortuitous result. This lends credibility to the notion that our MBI is effective in ameliorating stress, anxiety, and depression – and that listening to a health-oriented podcast may similarly benefit listeners. Finally, while the present study is not a clinical investigation, our results suggest the present 15-minute daily online MBI may hold promise for possible use in clinical research, given the observed reductions in psychopathological symptoms. Of course, future research must more robustly investigate such possibilities to establish more conclusive grounds for such speculation.

Trait Metacognition

Both the mindfulness and podcast groups also improved overall on trait metacognition – specifically, on the *Differentiation*, *Integration*, and *Mastery* subscales of the MSAS. This implies that subjects in both groups were better able to differentiate, integrate, and master the informational and practical components of the podcast and MBI by the end of the study – and that they could better apply this type of thinking during the second cognitive testing sessions.

Prior research has demonstrated that metacognition is intimately related to mindfulness (Hussain, 2015). Mindfulness is to some extent a metacognitive exercise. Indeed, Jankowski and Holas (2014) propose an intuitive metacognitive model of mindfulness. Moreover, Solem et al. (2015) showed that mindfulness and metacognition overlap considerably in their factor structures; the FFMQ subscales of nonjudging and acting with awareness loaded onto

metacognition, while observing, nonreacting, and describing formed a unique mindfulness factor (notably, observing and nonreacting were both significant in our own analysis). Thus, it's possible that increases in trait and state mindfulness observed for the MBI group may have further contributed to their increases in trait metacognition.

The podcast group's increase in trait metacognition being equivalent to the MBI group could be because the podcast requires conscious and sustained attentional awareness of the general contents of the audio stream. This ongoing awareness would allow for differentiation of key concepts or themes, and integration of present audio content into the context of both the broader subject matter and one's own subjective memories, mental schemas, and stream of consciousness.

Importantly, differentiation, integration, and mastery (our significant subscale scores) are also all heavily involved in learning and memory – as is trait metacognition overall (Efklides, 2006; Hong & O'Neil Jr., 2001). McCormick, Dimmitt, and Sullivan (2013) conceptualize metacognition as a conscious subcomponent of self-regulation that contributes to learning and cognitive control. On this view, self-regulation involves metacognitive awareness whereby individuals monitor, direct, and regulate thoughts and actions towards goals (Gitomer et al., 1987; Paris & Paris, 2001). Given the association between increased trait metacognition and better learning and memory (Buratti et al., 2013), it's reasonable to think that the increased trait metacognition scores for both groups may have led to concomitant improvements in learning and memory – which is also supported by the improvements to subjects' working memory performance for both groups.

Mindfulness and Metacognition: Distinct Yet Highly Related

Participants in both groups increased in trait metacognition (specifically, on MSAS subscales of differentiation, integration, and mastery), and the MBI group (but not the podcast group) improved on our trait mindfulness measure (specifically, two FFMQ-SF subscales of observing and nonreactivity). One of our guiding research questions involved how mindfulness

and metacognition are distinct. Related to this question, our results lend support to the notion that they are in fact distinct but highly related. Our correlational analyses between the five FFMQ and MSAS subscales showed considerable overlap between subscales, including some of those which were significant in our main analysis.

Moreover, the correlations between the FFMQ and MSAS (overall and subscales) changed considerably from session one to session two. For example, at session one, FFMQ and MSAS overall scores shared 46.87% variance – but by session two, overall, the correlation between these two scales increased to a considerable 65.07%. In other words, after the intervention period, by testing session two, mindfulness and metacognition became more highly related. This makes sense given the observed increases in trait mindfulness and metacognition in our present context. Interestingly, the most highly correlated measures were between the MSAS *monitoring* subscale and the FFMQ overall. This suggests that dispositional mindfulness and mindfulness practice could contribute to increases in metacognitive self-monitoring.

Another interesting finding is that the nature of the overlap between FFMQ and MSAS subscales also changed. In general, from session one to two, the overlap for most significant subscales increased, except for the overlap between *decentration* (MSAS) and *describing* (FFMQ) which was present in session one but absent in session two. In addition, the *observing* (FFMQ) subscale at session one was significantly related to the *monitoring* (MSAS) subscale – and not only did the size of this correlation increase but observing was also significantly correlated at session two with the *mastery* (MSAS) subscale and MSAS overall (both significant for both groups in our analysis). Similarly, *nonreactivity* (FFMQ) was correlated with mastery in session one – but by session two correlations also became significant with integration (significant in our analysis), monitoring, and overall MSAS scores. Interestingly, *nonjudgment* (FFMQ) was not significantly correlated with the MSAS nor its subscales at session one, but by session two it was correlated with all three of integration, mastery, monitoring, and metacognition overall. Notably, these results diverge somewhat from those found by Solem et

al. (2015), who found that observing, nonreacting, and describing formed a unique mindfulness factor while nonjudgment and acting with awareness formed a unique metacognition factor.

Thus, overall, there was a large degree of shared variance between subscales of mindfulness and metacognition, suggesting the two are distinct but highly related– which may become more related as facets of both subjectively increase. Given the large degree of shared variance between the two, it's plausible that mindfulness and metacognition are in fact part of some more general underlying cognitive construct. Notably, the degree of shared variance is not so high that we might consider mindfulness and metacognition as unitary, in support of the idea that mindfulness and metacognition are distinct. However, the overlap between the two is high enough that it's plausible that mindfulness and metacognition may be tapping some underlying unitary and more general latent factor.

One possibility is that mindfulness and metacognition are part of some domain-general or domain-specific (or both) latent factor which relates to *adaptive functioning* (AF). For example, Sahdra et al. (2011) used similar variables to ours, including measures of anxiety, depression, Big Five traits, and trait mindfulness, as well as a response inhibition task to measure attentional control (importantly, however, they did not measure metacognition). Their structural model grouped the mindfulness, trait, and mood factors into a single latent AF factor, which improved as a function of a mindfulness retreat relative to a no-retreat control group. In other words, mindfulness practice increased AF – which may be underpinned not only by trait mindfulness, but also trait metacognition (and their related facets).

Jankowski and Holas (2014) suggest that there are two hierarchical metacognitive levels, and that mindfulness is related to the highest levels of metacognition and metacognitive knowledge about oneself promotes mindfulness. Metacognition is a higher-order factor required to differentiate, integrate, and master control of lower-order (object-level) internal mental or cognitive processes – and mindfulness is an even higher-order process which regulates metacognitive knowledge and self awareness in service of mindful practices, behaviours, and

perceptions. In other words, lower order mental processes are the object of metacognitive thought – and metacognitive thoughts and skills themselves are the object of mindful meta-metacognitive thought. Notably, this model assumes that mindfulness and metacognition are two distinct yet interrelated processes – which fits with conclusions that we may draw from our own results. It makes sense, for example, that given the relationship between mindfulness and metacognition, as both change (increase) in the individual, so does the relationship between mindful and metacognitive thoughts and behaviours. The model also offers support for the notion of something like AF which may involve both mindfulness and metacognition. Our results thus offer decent support for the Jankowski and Holas (2014) conception of a metacognitive model of mindfulness, and suggest these concepts may be underpinned by a single latent factor related to overall adaptive functioning, which may have clinical relevance.

Null Results

Though trait metacognition was improved overall, the *decentration* and *monitoring* aspects of trait metacognition were both nonsignificant. This is surprising, considering that mindfulness crucially involves decentration of attention away from runaway thoughts and cognitions (Jankowski & Bąk, 2019) and ongoing recentering of attention on present moment awareness. Decentration is also purportedly a primary mechanism for positive therapeutic change with mindfulness practice (Isbel & Mahar, 2015). Thus, decentration is an aspect we might focus on to improve our MBI in the future, perhaps by including more explicit instructions of decentration. Alternatively, shifts in decentration may take more prolonged mindfulness practice than that offered by our present 15-minute daily 31-day MBI.

Moreover, Lindsay & Creswell (2017, 2019) propose a Monitoring and Acceptance Theory (MAT) about underlying mechanisms of mindfulness, which includes *attention monitoring* to explain how mindfulness improves cognitive functioning, and *acceptance* to reduce affective reactivity (i.e. increase non-reactivity). Interestingly, our analysis found significant increases for nonreactivity for the MBI group, but neither group experienced an

increase in monitoring. Thus, our null results for the monitoring subscale of trait metacognition seem surprising considering the MAT framework. Such null results also suggests that monitoring capacity is an aspect to consider when refining and improving our own MBI (or perhaps this would come with extended practice). Recent results by Simione et al. (2021) also suggest that acceptance reduces psychological symptoms and increases wellbeing – but not its interaction with monitoring, as monitoring only marginally predicted few outcomes.

LTM, EI, and attention measures were also all nonsignificant. The null results for LTM are surprising given that moderate evidence exists for a possible influence of mindfulness on memory, both short- and long-term. Lykins et al. (2012) demonstrated improvements in both short-term and long-term memory for a group of experienced mindfulness meditators versus a demographically matched group of nonmeditators (i.e. meditation-naïve participants, such as our present sample). Notably, in that study, this positive LTM result was shown for free recall memory specifically – but not recognition memory. This parallels our own null result for our recognition memory task, which may suggest a reason why we didn't see results in our sample. It's possible that if we'd used a free recall memory test, we might have observed significant results. However, Brown et al. (2016) demonstrated an improvement in LTM, specifically, recognition memory performance on a Remember-Know paradigm – suggesting that recognition memory can benefit from a brief MBI. Thus, it's also possible that the nature of our task was insufficient to capture possible LTM memory improvements in the mindfulness group. It's also possible that cognitive fatigue played a role, given the number of consecutive cognitive tests involved in our testing; participants had to do over 20 minutes of cognitive testing before doing the recognition phase of the LTM task, so it's possible this interfered with recognition memory performance in our study.

Notably, the Lykins et al. (2012) study just noted also found null results for their attentional measures – much like our own results. Nonetheless, our null results for attention were somewhat surprising because improvements in attention have been demonstrated across

several studies. For example, Isbel et al. (2020) showed attentional improvements on the SART in a sample of older adults, including unique frontal P3 latency improvements on EEG measurements for the mindfulness over control group. Jha et al. (2007) used the Attention Network Test (ANT) to measure attention and demonstrated mindfulness-related improvements in neural attentional systems involved in the orienting response and conflict monitoring. Morrison and Jha (2015) noted the considerable overlap with working memory and attention, and their positive relationship with mindfulness. Given that our own results showed significant (though group-independent) improvements in working memory, this makes the null attentional results even more surprising.

One possibility is that since students' lives were quite busy with school and personal lives, attention was divided between the task at hand (mindfulness/podcast, or cognitive tests), and other urgent matters (e.g. exams, assignment deadlines, personal commitments, etc.). Attention may have been pulled in other directions, leading to less engagement with the mindfulness meditation, podcast, or testing. Moreover, this aligns with what some subjects reported in their post-session subjective experience feedback. For example, subjects from both groups occasionally (though infrequently) reported that they were distracted from the task due to school-related obligations or personal commitments. Notably, the study period also overlapped with the students' midterm period, so they saw an increase in assignments and exams (and related commitments) during the study. Another possibility is that attentional effects were not observed since prefrontal cortical development in emerging adults (i.e. our present sample) is not fully complete until the mid-twenties (Gogtay, 2004; Taber-Thomas & Pérez-Edgar, 2015). It's possible attentional resources were not sufficiently developed in our sample to manifest significant attentional effects, such as those observed in (fully developed) older adults on the SART by Isbel and colleagues (2020).

Lastly, the EI null results were also surprising. For example, Gallant (2016) found that out of six studies measuring EI, all but one found an effect of mindfulness on EI measures.

Given that we used an affective Stroop task, it's possible that the additional emotional cognitive load could potentially have influenced results. However, an fMRI study by Allen et al. (2012) also used an affective Stroop task to demonstrate reduced Stroop interference (i.e. improved executive inhibition) in the mindfulness group but not controls. Notably, they also found mindfulness-related BOLD shifts over time in the dorsolateral prefrontal cortex. Moore and Malinowski (2009) also found that higher trait mindfulness was associated with greater inhibitory processing – and Teper and Inzlicht (2013) found increased error-related negativity (ERN) in EEG signals in mindfulness meditators. Thus, the null results for executive inhibition are surprising.

Finally, it's possible the demands of the cognitive testing played some role in our null results. That is, it's possible that the cognitive load in the present study was too great, given the number of back-to-back cognitive performance tests. Subjects may have been too fatigued by the end of testing to perform well on the recognition phase of the LTM task – or too cognitively fatigued in general by preceding cognitive tasks. For example, if a participant were presented with the Stroop and N-back tasks prior to the SART (as some were), they may have been more cognitively fatigued and less attentive to the attention task.

Similarity of Interventions

As noted, contrary to our hypothesis, *both* groups experienced significant beneficial shifts in WM, trait stress, trait anxiety, depression, and trait metacognition. This joint improvement of the MBI and podcast groups across a range of variables is likely due, at least in part, to the considerable number of relevant similarities (several explored below) between the experimental mindfulness and podcast control interventions.

Firstly, both interventions are self-focused, albeit in slightly different ways. The mindfulness intervention is *directly* focused on self-reflection and introspection, whereas the podcast intervention is *indirectly* (though at times directly) self-reflection focused. For the podcast group, it's reasonable to expect that subjects will think about how the health education

and scientific tools for wellbeing offered by the podcast may apply to their own lives. This line of thinking is further supported by prior research which demonstrated that an experiential mode of self-focus that is oriented towards observing and integrating moment-by-moment experience and emotions, rather than conceptual-evaluative judgments, leads to adaptive self-focus (Watkins, 2004). Huffziger and Kuehner (2009) also showed that mindful self-focus, induced via an MBI, significantly decreased negative mood in depressive patients. Precisely this type of experiential and mindful self-focus is ostensibly present in *both* interventions in our study, which may help to account for the observed joint changes.

Secondly, both interventions incorporate elements of psychoeducation, explaining certain context-specific tenets or principles of health and wellbeing (though the podcast notably did not explain principles of mindfulness, which was unique to the MBI group). Health education has also been shown to help reduce negative health behaviours (e.g. Schwarzer, 2008; Kok et al., 2011), which may plausibly lead to improvements in health and wellbeing (Steckler et al., 1995). A meta-analysis of 19 studies by Van Daele and colleagues (2012) showed that psychoeducation can facilitate stress reduction. A 2021 study by Hood and colleagues during the COVID-19 pandemic showed that psychoeducational courses are beneficial to mood in both live and online formats, even in times of collective stress and uncertainty such as the pandemic. Thus, psychoeducation may have played a role in improving stress, anxiety, and depression scores in our present study. Additionally, decreases in stress, anxiety, and depression may have simultaneously contributed to WM improvements (Lukasik et al., 2019; Rose & Ebmeier, 2006; Andreotti et al., 2013).

Thirdly, both interventions were delivered online, via 15-minute audio segments to participants and a few features of those audio segments are similar. For example, both audio files offered a natural male voice with no background music or noise, presenting a clear (and similar) stimulus signal for both groups. It's also possible that both interventions' online delivery through an identical format via our internet module could have accounted for some of the

similarity in results. Internet-based health interventions are efficacious for a diverse variety of both physical (e.g. Lustria et al., 2009) and mental (e.g. Barak & Grohol, 2011; Clarke et al., 2015) health interventions. As already noted, online MBIs are well-demonstrated as effective in improving mental health outcomes (Spijkerman et al., 2016), though more specific information is relatively lacking and under empirical investigation.

Robust research on podcast interventions is relatively lacking, but promising results show that podcasts can be beneficial for improving happiness and wellbeing (Dreer, 2021); weight loss (Turner-McGrievy et al., 2009); parenting efficacy (Morawska et al., 2014); delivering medical education (O'Connor et al., 2020; Kelly et al., 2022); and even for delivering a mindfulness intervention (Karing, 2022). Thus, it stands to reason that the online nature of our intervention had an influence for both the mindfulness and podcast groups alike.

Finally, it's also noteworthy that in their post-session daily feedback, both intervention groups on average rated the interventions as equally enjoyable, engaging, and useful over the 31-day course of daily sessions. This implies that subjects enjoyed and were engaged in the mindfulness and podcast tasks equivalently. Tasks that are enjoyable and engaging are more intrinsically meaningful and motivating (Waterman, 2005). Therefore, one possibility is that intrinsic motivation for both tasks was high given their enjoyability, which may have combined with the extrinsic motivation (financial compensation, social accountability to researcher, goal completion) to facilitate improvements in cognition, mood, and personal characteristics in both groups.

In sum, the two interventions we designed for this study were quite effective – but perhaps insufficiently dissimilar to fully support our hypothesis that the MBI group would see unique improvement across our outcome variables and that the podcast group would not. Our results highlight the importance of selecting a proper control intervention that is adequately matched to the experimental intervention. This appears to be the case in our present study: the podcast intervention as a control group was comparably effective relative to the mindfulness

intervention – and this is likely due in part to the considerable similarities between our experimental and control interventions (setting aside unique MBI group improvements in dispositional mindfulness, which suggest something unique about the MBI).

Benefits to Both Groups

Of course, the fact that both groups saw benefit from their interventions may be considered a strength – especially when viewed from the perspective of the participant and their wellbeing. Notably, these results also contribute to a growing body of research which indicates that science and health education-oriented podcast may help to improve cognitive and socioemotional functioning and individual characteristics in as little as 15 minutes per day. Unfortunately, our present design doesn't allow us to disentangle these observed effects from any intervention that imposes some structured routine on participants' daily lives (e.g. listening each day to 15 minutes of someone reading from a phone book) – so the results must be interpreted cautiously. Still, this may warrant further research, and hints at the efficacy of a science and health education podcast in influencing psychosocial outcomes and wellbeing.

Differences Between Interventions

Despite many similarities between the interventions, it's worth mentioning that there were still key differences between the MBI and podcast interventions. For example, the mindfulness audio file was the exact same file presented each day (i.e. MBI participants heard the same audio content every day). In contrast, the podcast segment changed in content each day – though there was still continuity between segments in terms of content, format of the podcast, the host's voice, etc. In this way, the mindfulness intervention focused on one subject (i.e. learning/practicing mindfulness), whereas the podcast focused on a diverse range of independent topics across the four episodes and 31 audio segments. Thus, the subject matter and content of the two interventions was qualitatively different.

The MBI also specifically trained the two core skills of mindfulness, represented by two meditative styles: focused attention (FA) on the present moment and open monitoring (OM)

involving nonjudgmental monitoring and awareness of the contents of experience (Isbel & Summers, 2017). Importantly, the MBI involves a hybrid approach, with progression from FA style practice to more OM style practice. In contrast, the podcast intervention trained FA only, via active listening; notably, in this way, the podcast condition may be considered quasi-meditative. So, the MBI group combined both FA and OM meditation styles while the podcast group experienced only FA-style quasi-meditation.

Cullen et al. (2021) compared FA and OM style meditations with an MBCT intervention and found that all three showed different response patterns on indices of stress, depression, and anxiety. FA specifically showed the fastest improvement and fewest deteriorations over time in stress, anxiety, and depression. This suggests that FA-style meditations are what help improve cognition, depression, stress, and anxiety most rapidly (see also Ainsworth et al., 2013). Since our MBI and podcast intervention both involve FA-style techniques, this may therefore be a significant contributing factor to the improvements in depression, anxiety, and stress seen for both groups in our present study. Moreover, the progression from FA to OM style meditation for the MBI group could plausibly be partly responsible for the results that showed significant unique effects on the experimental group (i.e. state and trait mindfulness, and state stress). Accordingly, this progression from FA to OM meditation (exercising of both styles) represents a possible unique advantage of the MBI.

It’s also reasonable to think that mutual improvements in WM could similarly be related to this FA-style meditative component. For example, Osaka et al. (2007) showed that focusing attention activated brain regions known to be involved in WM, including the superior parietal lobule, anterior cingulate, and dorsolateral prefrontal cortices. Additionally, Souza and colleagues (2014) demonstrated that focusing attention improved WM. Thus, joint WM improvements may also stem partly from the similar FA-style qualities involved in both our interventions.

Another key difference is that our MBI – in addition to being more relaxing (i.e. decreasing stress better) – was significantly more *challenging* than the podcast intervention. This makes sense considering that, as noted, the MBI group had to learn and practice a skill, while the podcast group did not. Thus, overall, the MBI group was substantially more challenged by their intervention than the podcast group was. One interesting possibility is that the challenging nature of the MBI uniquely benefitted the mindfulness group. For example, participants might have experienced reduced stress because they completed the challenging-but-manageable daily task, triggering reward in the brain and improved mood. Alternatively, the challenge itself might have been intrinsically rewarding and motivating for some participants (this accords with some participants' post-session subjective reports). Unfortunately, the present design is insufficient to address these possibilities – so they remain open for future inquiry.

Limitations and Future Directions

A key limitation to our study is that it's unclear whether mindfulness and podcast listening are explicitly responsible for the improvements observed in our sample across our variables of interest – or whether it's simply being engaged in a meaningful, structured and motivationally salient task that produces the effects (or even just a task in general). For example, it's possible that joint improvements might stem from simply listening to an audio file with a conversational male voice for 15 minutes. Alternatively, being engaged in a task *in general* that is meaningful-but-challenging may have also contributed.

Notably, the principal investigators initially debated whether to use an active podcast control group or a passive wait-list control group. Ultimately, we opted to use an active control intervention and match the intervention closely enough to the MBI that it was relevant, but not so close as to be the same. Our results seem to indicate that we matched the two interventions extremely well – and this ended up generating unique questions worthy of further empirical research. Future research might seek to use different control group types, or include more than

one control condition. Wait-list control groups are common in empirical investigations of MBIs and offer unique benefits, as the control group later serves as a second experimental group.

Other limitations to our study relate to our sample size and quality. Overall, the quality of our sample is high and the size adequate. Still, while our sample size was sufficient to detect medium-to-large effect sizes, we are statistically underpowered to be able to detect smaller effect sizes. A meta-analysis by Ethbert and Sedlmeier (2012) found small-to-medium effect sizes of mindfulness meditation on outcome variables across 39 studies selected for analysis. Therefore, though unlikely, it's possible that our smaller sample size and insufficient statistical power to detect small-to-medium effects influenced our results in some way, or that we failed to detect other intervention effects. Future research might therefore increase sample size. Lastly, our sample included predominantly women (76%); thus, gender may have influenced the results in some meaningful but undetected way.

Another issue is that we eliminated the social component of the standardized MBI almost entirely. Uziel (2007) showed that the social presence of others elicits a positive-self-assured response – and better mood in a socially positive mindfulness setting may lead to improved cognition and wellbeing. Moreover, a recent meta-analysis by Strohmaier (2020) showed significant dose-response relationships for MBIs for face-to-face contact, program intensity, and actual intervention use. Notably, our present study eliminated face-to-face contact and most of the social component of the mindfulness intervention entirely. Ultimately, this may have influenced results by decreasing social benefits from the in-person element of mindfulness training, possibly contributing to our few null results.

Related to dose dependence for mindfulness practice, though there are few randomized controlled trials on this issue and there's no "one-size-fits-all" when it comes to mindfulness practice dosage, it's likely there is a dose-dependent relationship between mindfulness practice and related benefits (Creswell, 2017). Overall, our MBI group could only accumulate a maximum of 7.75 hours of mindfulness practice under ideal performance conditions where they

do 15 minutes daily for 31 days (and notably, only one participant in our study completed all 31 possible sessions). Thus, it's possible that our mindfulness intervention was too brief to manifest some expected cognitive and individual trait effects – and that additional practice time could hypothetically lead to such effects. This intuitively suggests that shortening our MBI could come at the cost of some more long-term effects seen with longer MBIs – and that shorter MBIs may best be viewed as a tool for bridging people to longer-term mindfulness protocols and practices, which lead to more lasting cognitive changes as total practice time increases.

Another limitation of our design includes the length and intensity of our cognitive testing, as noted. Our testing battery included four consecutive and demanding cognitive tasks. Participants completed about 30 minutes of cognitive testing in both testing sessions – which could have negatively impacted cognitive performance. The first tasks performed could plausibly have contributed to cognitive fatigue and performance impairment on the latter tasks and LTM recall phase. Future research might reduce this by limiting the number, intensity, and duration of cognitive tasks that subjects are required to perform.

Finally, future research might seek to establish the long-term benefits of brief online MBIs. It remains unclear what is the minimum dose (i.e. meditation time), per session and overall, required to maximize benefit, and precisely how long MBI-related changes endure in the absence of practice. Relatedly, future research might seek to plot a time course of mindfulness benefits and how those progress as mindfulness practice increases – as well as how they are preserved (or deteriorate) when mindfulness practice decreases or ceases entirely.

Summary and Conclusions

In summary, we found evidence for unique effects of our brief 15-minute daily online MBI on state and dispositional mindfulness, and state stress. After 31 days, the MBI group was significantly more dispositionally mindful and more relaxed (less stressed) at the state level compared to the active podcast control group. Moreover, we found that both the podcast and MBI groups improved across a range of variables including working memory, trait

metacognition, trait stress, trait anxiety, and depression. Both groups also marginally changed in trait openness and agreeableness. Surprising null results were found for executive inhibition, long-term memory, and attention. Considering the overlap of our results and similarities between our two interventions, it seems our groups' intervention tasks may have been very well matched and thus yielded similar but nonspecific improved results, although this explanation would not account for the null results for the majority of the cognitive assessments. Future research might seek to deploy different control interventions that are more mutually distinct and different cognitive tasks which may more adequately capture MBI-related changes.

We found partial support for our initial set of hypotheses. The MBI group uniquely improved on dispositional and state-level mindfulness and state-level relaxation, which we took as a proxy for state-level stress. However, they did not experience unique improvements across any other variables of interest. Moreover, contrary to our hypotheses, the podcast group improved jointly with the MBI group in terms of overall cognitive and socio-affective functioning and individual differences.

Nonetheless, we demonstrate robust results in line with prior research on brief online MBIs and dispositional mindfulness. In terms of our guiding research questions, we found that our adapted, standardized, brief daily online MBI was indeed effective in improving some aspects of cognitive performance, socio-affective functioning, and dispositional mindfulness and other trait factors. Moreover, the online MBI induced state-level shifts in dispositional mindfulness which contributed to enduring and specific trait-level changes. Finally, we found mindfulness and metacognition to be distinct yet highly related constructs, possibly underpinned by some other general latent factor**.**

In conclusion, we've found preliminary support for use of our brief 31-day, 15-minute daily online MBI, which may be optimized in future research. We suggest ours and other similar brief online MBIs may be used most effectively as a bridge to short-term cognitive and wellbeing enhancements, as well as longer-term practices and related cumulative benefits. Moreover, a

deeper understanding of brief MBIs may help generate or validate a more robust multi-level theory of why certain MBIs are useful as clinical or general wellbeing improvement instruments – and for which populations, in what contexts, and under what parameters mindfulness practice is effective. This will ultimately enable us to optimize and tailor mindfulness protocols for practitioners' particular needs and success conditions, while helping to avoid unfair misrepresentation of mindfulness as a panacea which helps everyone homogenously.

References

Ainsworth, B., Eddershaw, R., Meron, D., Baldwin, D. S., & Garner, M. (2013). The effect of focused attention and open monitoring meditation on attention network function in healthy volunteers. *Psychiatry Research, 210*(3), 1226–1231. https://doi.org/10.1016/j.psychres.2013.09.002

Allen, M., Dietz, M., Blair, K. S., van Beek, M., Rees, G., Vestergaard-Poulsen, P., ... Roepstorff, A. (2012). Cognitive-affective neural plasticity following active controlled mindfulness intervention. *The Journal of Neuroscience 32*, 15601–15610. http://dx.doi.org/10.1523/jneurosci.2957-.

Andersson, G., & Cuijpers, P. (2009). Internet-based and other computerized psychological treatments for adult depression: A meta-analysis. *Cognitive Behaviour Therapy, 38*(4), 196–205. https://doi.org/10.1080/16506070903318960

Andersson, G., Carlbring, P., & Cuijpers, P. (2010). Internet interventions: Moving from efficacy to effectiveness. *EJAP (Test), 5*, 9–17. https://doi.org/10.7790/ejap.v5i2.169

Andreotti, C., Thigpen, J. E., Dunn, M. J., Watson, K., Potts, J., Reising, M. M., Robinson, K. E., Rodriguez, E. M., Roubinov, D., Luecken, L., & Compas, B. E. (2013). Cognitive reappraisal and secondary control coping: Associations with working memory, positive and negative affect, and symptoms of anxiety/depression. *Anxiety, Stress, & Coping, 26*(1), 20–35. https://doi.org/10.1080/10615806.2011.631526

Austin, M., & Loprinzi, P. D. (2019). Acute exercise and mindfulness meditation on learning and memory: randomized controlled intervention. *Health Promotion Perspectives 9*(4), 314-318. https://dx.doi.org/10.15171%2Fhpp.2019.43

Banks, J. B., Welhaf, M. S., & Srour, A. (2015). The protective effects of brief mindfulness meditation training. *Consciousness and Cognition 33*, 277–285. https://doi.org/10.1016/j.concog.2015.01.016

Barak, A., & Grohol, J. M. (2011). Current and future trends in internet-supported mental health interventions. *Journal of Technology in Human Services, 29*(3), 155–196. https://doi.org/10.1080/15228835.2011.616939

Baranski, M., & Was, C.A. (2017). Mindfulness meditation may not increase false-memory and may instead protect from false-memory susceptibility. *Mindfulness 8*, 1569–1579. https://doi.org/10.1007/s12671-017-0729-7

Bao, X., Xue, S., & Kong, F. (2015) Dispositional mindfulness and perceived stress: The role of emotional intelligence. *Personality and Individual Differences, 78*, 48-52. http://dx.doi.org/10.1016/j.paid.2015.01.007

Ben-Haim, M. S., Williams, P., Howard, Z., Mama, Y., Eidels, A., & Algom, D. (2016). The Emotional Stroop Task: Assessing cognitive performance under exposure to emotional content. *Journal of Visualized Experiments, 112*, 53720. https://doi.org/10.3791/53720

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., Segal, Z. V., Abbey, S., Speca, M., Velting, D., & Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice, 11*, 230–241. https://doi.org/10.1093/clipsy.bph077

Bohlmeijer, E., ten Klooster, P. M., Fledderus, M., Veehof, M., & Baer, R. (2011). Psychometric properties of the Five Facet Mindfulness Questionnaire in depressed adults and

development of a short form. *Assessment, 18*(3), 308–320. https://doi.org/10.1177/1073191111408231

Bränström, R., Duncan, L. G., & Moskowitz, J. T. (2011). The association between dispositional mindfulness, psychological well-being, and perceived health in a Swedish population-based sample. *British Journal of Health Psychology, 16*(2), 300–316. https://doi.org/10.1348/135910710X501683

Bremer, B., Wu, Q., Mora Álvarez, M. G., Hölzel, B. K., Wilhelm, M., Hell, E., Tavacioglu, E. E., Torske, A., & Koch, K. (2022). Mindfulness meditation increases default mode, salience, and central executive network connectivity. *Scientific Reports, 12*(1), Article 1. https://doi.org/10.1038/s41598-022-17325-6

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology 84*, 822–848. https://doi.org/10.1037/0022-3514.84.4.822

Brown, K.W., Goodman, R.J., Ryan, R.M., Anālayo, B. (2016). Mindfulness enhances episodic memory performance: Evidence from a multimethod investigation. *PLOS ONE 11*(4): e0153309. https://doi.org/10.1371/journal.pone.0153309

Brysbaert, M., & New, B. (2009). Moving beyond Kučera and Francis: A critical evaluation of current word frequency norms and the introduction of a new and improved word frequency measure for American English. *Behavior Research Methods, 41*(4), 977–990. https://doi.org/10.3758/BRM.41.4.977

Buratti, S., Allwood, C. M., & Kleitman, S. (2013). First- and second-order metacognitive judgments of semantic memory reports: The influence of personality traits and cognitive

styles. *Metacognition and Learning, 8*(1), 79–102. https://doi.org/10.1007/s11409-013-9096-5

Cavanagh, K., Strauss, C., Cicconi, F., Griffiths, N., Wyper, A., & Jones, F. (2013). A randomised controlled trial of a brief online mindfulness-based intervention. *Behaviour Research and Therapy, 51*(9), 573–578. https://doi.org/10.1016/j.brat.2013.06.003

Chen, Y.-F., & Peng, S. S. (2008). University students' internet use and its relationships with academic performance, interpersonal relationships, psychosocial adjustment, and self-evaluation. *CyberPsychology & Behavior, 11*(4), 467–469. https://doi.org/10.1089/cpb.2007.0128

Chiesa, A., Calati, R., & Serretti, A. (2011). Does mindfulness training improve cognitive abilities? A systematic review of neuropsychological findings. *Clinical Psychology Review, 31*(3), 449–464. https://doi.org/10.1016/j.cpr.2010.11.003

Chiesa, A., & Malinowski, P. (2011). Mindfulness-based approaches: Are they all the same? *Journal of Clinical Psychology, 67*(4), 404–424. https://doi.org/10.1002/jclp.20776

Chiesa, A., & Serretti, A. (2009). Mindfulness-Based Stress Reduction for stress management in healthy people: A review and meta-analysis. *The Journal of Alternative and Complementary Medicine, 15*(5), 593–600. https://doi.org/10.1089/acm.2008.0495

Chiesa, A., & Serretti, A. (2011). Mindfulness based cognitive therapy for psychiatric disorders: A systematic review and meta-analysis. *Psychiatry Research, 187*(3), 441–453. https://doi.org/10.1016/j.psychres.2010.08.011

Clarke, A. M., Kuosmanen, T., & Barry, M. M. (2015). A systematic review of online youth mental health promotion and prevention interventions. *Journal of Youth and Adolescence, 44*(1), 90–113. https://doi.org/10.1007/s10964-014-0165-0

Cohen, S., & Williamson, G. (1988). *Perceived stress in a probability sample of the United States*. In S. Spacapan & S. Oskamp (Eds.), The social psychology of health (pp. 31–68). Newbury Park, CA: Sage.

Creswell, J. D. (2017). Mindfulness interventions. *Annual Review of Psychology, 68*(1), 491–516. https://doi.org/10.1146/annurev-psych-042716-051139

Creswell, J. D., & Lindsay, E. K. (2014). How does mindfulness training affect health? A mindfulness stress buffering account. *Current Directions in Psychological Science, 23*(6), 401–407. https://doi.org/10.1177/0963721414547415

Cullen, B., Eichel, K., Lindahl, J. R., Rahrig, H., Kini, N., Flahive, J., & Britton, W. B. (2021). The contributions of focused attention and open monitoring in mindfulness-based cognitive therapy for affective disturbances: A 3-armed randomized dismantling trial. *PLOS ONE, 16*(1), e0244838. https://doi.org/10.1371/journal.pone.0244838

Dawson, A. F., Brown, W. W., Anderson, J., Datta, B., Donald, J. N., Hong, K., Allan, S., Mole, T. B., Jones, P. B., & Galante, J. (2020). Mindfulness-based interventions for university students: A systematic review and meta-analysis of randomised controlled trials. *Applied Psychology: Health and Well-Being, 12*(2), 384–410. https://doi.org/10.1111/aphw.12188

De Leeuw, J. R. (2015). jsPsych: A JavaScript library for creating behavioral experiments in a Web browser. *Behavior Research Methods*, *47*(1), 1–12. https://doi.org/10.3758/s13428-014-0458-y

Dreer, B. (2021). Fostering well-being over the radio? An empirical study investigating the effects of an audio podcast-based intervention program on student teachers' well-being. *International Journal of Community Well-Being, 4*(4), 603–623. https://doi.org/10.1007/s42413-020-00105-3

Dusek, J. A., & Benson, H. (2009). Mind-body medicine: A model of the comparative clinical impact of the acute stress and relaxation responses. Minnesota Medicine, 92(5), 47–50.

Eberth, J., & Sedlmeier, P. (2012). The effects of mindfulness meditation: A meta-analysis. *Mindfulness, 3*(3), 174–189. https://doi.org/10.1007/s12671-012-0101-x

Edenfield, T. M., & Saeed, S. A. (2012). An update on mindfulness meditation as a self-help treatment for anxiety and depression. *Psychology Research and Behavior Management 5*, 131-141. https://dx.doi.org/10.2147%2FPRBM.S34937

Efklides, A. (2006). Metacognition and affect: What can metacognitive experiences tell us about the learning process*? Educational Research Review, 1*(1), 3–14. https://doi.org/10.1016/j.edurev.2005.11.001

Esch, T. (2014). The neurobiology of meditation and mindfulness. In S. Schmidt & H. Walach (Eds.), Meditation – *Neuroscientific Approaches and Philosophical Implications* (pp. 153–173). Springer International Publishing. https://doi.org/10.1007/978-3-319-01634-4_9

Farb, N. A. S., Segal, Z. V., Mayberg, H., Bean, J., McKeon, D., Fatima, Z., & Anderson, A. K. (2007). Attending to the present: Mindfulness meditation reveals distinct neural modes of self-reference. *Social Cognitive and Affective Neuroscience, 2*(4), 313–322. https://doi.org/10.1093/scan/nsm030

Friedman, N. P., & Miyake, A. (2017). Unity and diversity of executive functions: Individual differences as a window on cognitive structure. *Cortex, 86*, 186–204. https://doi.org/10.1016/j.cortex.2016.04.023

Gallant, S. N. (2016). Mindfulness meditation practice and executive functioning: Breaking down the benefit. *Consciousness and Cognition, 40*, 116–130. https://doi.org/10.1016/j.concog.2016.01.005

Gitomer, D. H., Curtis, M. E., Glaser, R., & Lensky, D. B. (1987). Processing differences as a function of item difficulty in verbal analogy performance. *Journal of Educational Psychology, 79*, 212–219. https://doi.org/10.1037/0022-0663.79.3.212

Gogtay, N., Giedd, J. N., Lusk, L., Hayashi, K. M., Greenstein, D., Vaituzis, A. C., Nugent, T. F., Herman, D. H., Clasen, L. S., Toga, A. W., Rapoport, J. L., & Thompson, P. M. (2004). Dynamic mapping of human cortical development during childhood through early adulthood. *Proceedings of the National Academy of Sciences, 101*(21), 8174–8179. https://doi.org/10.1073/pnas.0402680101

Gorman, T. E., & Green, C. S. (2016). Short-term mindfulness intervention reduces the negative attentional effects associated with heavy media multitasking. *Scientific Reports, 6*(1), Article 1. https://doi.org/10.1038/srep24542

Gosling, S. D., Rentfrow, P. J., & Swann, W. B. (2003). A very brief measure of the Big-Five personality domains. *Journal of Research in Personality, 37*(6), 504–528. https://doi.org/10.1016/S0092-6566(03)00046-1

Green, A. A., & Kinchen, E. V. (2021). The effects of mindfulness meditation on stress and burnout in nurses. *Journal of Holistic Nursing, 39*(4), 356–368. https://doi.org/10.1177/08980101211015818

Grossman, P., Niemann, L., Schmidt, S., & Walach, H. (2004). Mindfulness-based stress reduction and health benefits: A meta-analysis. *Journal of Psychosomatic Research, 57*(1), 35–43. https://doi.org/10.1016/S0022-3999(03)00573-7

Haliwa, I., Wilson, J. M., Spears, S. K., Strough, J., & Shook, N. J. (2021). Exploring facets of the mindful personality: Dispositional mindfulness and the Big Five. *Personality and Individual Differences, 171*, 110469. https://doi.org/10.1016/j.paid.2020.110469

Henriksen, D., Richardson, C., & Shack, K. (2020). Mindfulness and creativity: Implications for thinking and learning. *Thinking Skills and Creativity, 37*, 100689. https://doi.org/10.1016/j.tsc.2020.100689

Hong, E., & O'Neil Jr, H. F. (2001). Construct validation of a trait self-regulation model. *International Journal of Psychology, 36*(3), 186–194. https://doi.org/10.1080/00207590042000146

Hood, B., Jelbert, S., & Santos, L. R. (2021). Benefits of a psychoeducational happiness course on university student mental well-being both before and during a COVID-19 lockdown. *Health Psychology Open, 8*(1), 2055102921999291. https://doi.org/10.1177/2055102921999291

Huffziger, S., & Kuehner, C. (2009). Rumination, distraction, and mindful self-focus in depressed patients. *Behaviour Research and Therapy, 47*(3), 224–230. https://doi.org/10.1016/j.brat.2008.12.005

Hussain, D. (2015). Meta-cognition in mindfulness: A conceptual analysis. *Psychological Thought, 8*(2), 132-141. https://doi.org/10.23668/psycharchives.1972

Isbel, B., Lagopoulos, J., Hermens, D., Stefanidis, K., & Summers, M. J. (2020). Mindfulness improves attention resource allocation during response inhibition in older adults. *Mindfulness, 11*(6), 1500–1510. https://doi.org/10.1007/s12671-020-01364-z

Isbel, B., & Mahar, D. (2015). Cognitive mechanisms of mindfulness: A test of current models. *Consciousness and Cognition, 38*, 50–59. https://doi.org/10.1016/j.concog.2015.10.005

Isbel, B., & Summers, M. J. (2017). Distinguishing the cognitive processes of mindfulness: Developing a standardised mindfulness technique for use in longitudinal randomised control trials. *Consciousness and Cognition, 52*, 75–92. https://doi.org/10.1016/j.concog.2017.04.019

Jankowski, T., & Bąk, W. (2019). Mindfulness as a mediator of the relationship between trait anxiety, attentional control and cognitive failures. A multimodel inference approach. *Personality and Individual Differences, 142*, 62–71. https://doi.org/10.1016/j.paid.2019.01.034

Jankowski, T., & Holas, P. (2014). Metacognitive model of mindfulness. *Consciousness and Cognition, 28*, 64–80. https://doi.org/10.1016/j.concog.2014.06.005

Jha, A. P., Krompinger, J., & Baime, M. J. (2007). Mindfulness training modifies subsystems of attention. *Cognitive, Affective, & Behavioral Neuroscience, 7*(2), 109–119. https://doi.org/10.3758/CABN.7.2.109

Jha, A. P., Denkova, E., Zensco, A. P., Witkin, J. E., Rooks, J., & Rogers, S. L. (2019). Does mindfulness training help working memory 'work' better? *Current Opinion in Psychology 28*, 273-278. https://doi.org/10.1016/j.copsyc.2019.02.012

Jiménez-Picón, N., Romero-Martín, M., Ponce-Blandón, J.A., Ramirez-Baena, L., Palomo-Lara, J.C., Gómez-Salgado, J. (2021) The relationship between mindfulness and emotional intelligence as a protective factor for healthcare professionals: Systematic review. *International Journal of Environmental Research and Public Health, 18*, 5491. https://doi.org/10.3390/ ijerph18105491

Jones, S. M., Bodie, G. D., & Hughes, S. D. (2019). The impact of mindfulness on empathy, active listening, and perceived provisions of emotional support. *Communication Research, 46*(6), 838–865. https://doi.org/10.1177/0093650215626983

Jopling, E., Gotlib, I. H., & LeMoult, J. (2020). Effects of working memory training on cognitive, affective, and biological responses to stress in major depression: A novel cognitive bias modification protocol. *Journal of Affective Disorders, 265*, 45–51. https://doi.org/10.1016/j.jad.2020.01.007

Kabat-Zinn, J. (2011). Some reflections on the origins of MBSR, skillful means, and the trouble with maps. *Contemporary Buddhism, 12*(1), 281–306. https://doi.org/10.1080/14639947.2011.564844

Kane, M., & Conway, A. (2016). The invention of n-back: An extremely brief history. The Winnower, 2003-2005.

Kang, C., & Whittingham, K. (2010). Mindfulness: A dialogue between Buddhism and Clinical Psychology. *Mindfulness, 1*(3), 161–173. https://doi.org/10.1007/s12671-010-0018-1

Karing, C. (2022). The efficacy of online mindfulness-based interventions in a university student sample: Videoconference- or podcast-delivered intervention. *Applied Psychology: Health and Well-Being*, 1-17. https://doi.org/10.1111/aphw.12408

Kaufman, S. B., Quilty, L. C., Grazioplene, R. G., Hirsh, J. B., Gray, J. R., Peterson, J. B., & DeYoung, C. G. (2016). Openness to experience and intellect differentially predict creative achievement in the arts and sciences. *Journal of Personality, 84*(2), 248–258. https://doi.org/10.1111/jopy.12156

Kee, Y. H., & Liu, Y.-T. (2011). Effects of dispositional mindfulness on the self-controlled learning of a novel motor task. *Learning and Individual Differences, 21*(4), 468–471. https://doi.org/10.1016/j.lindif.2011.01.009

Kelly, J. M., Perseghin, A., Dow, A. W., Trivedi, S. P., Rodman, A., & Berk, J. (2022). Learning through listening: A scoping review of podcast use in medical education. *Academic Medicine, 97*(7), 1079–1085. https://doi.org/10.1097/ACM.0000000000004565

Kersemaekers, W., Rupprecht, S., Wittmann, M., Tamdjidi, C., Falke, P., Donders, R., Speckens, A., & Kohls, N. (2018). A workplace mindfulness intervention may be associated with improved psychological well-being and productivity. A preliminary field study in a company setting. *Frontiers in Psychology, 9*. https://doi.org/10.3389/fpsyg.2018.00195

Khoury, B., Sharma, M., Rush, S. E., & Fournier, C. (2015). Mindfulness-based stress reduction for healthy individuals: A meta-analysis. *Journal of Psychosomatic Research, 78*(6), 519–528. https://doi.org/10.1016/j.jpsychores.2015.03.009

Kiken, L. G., Garland, E. L., Bluth, K., Palsson, O. S., & Gaylord, S. A. (2015). From a state to a trait: Trajectories of state mindfulness in meditation during intervention predict changes in trait mindfulness. *Personality and Individual Differences, 81*, 41–46. https://doi.org/10.1016/j.paid.2014.12.044

Kok, G., Schaalma, H., De Vries, H., Parcel, G., & Paulussen, T. (1996). Social psychology and health education. *European Review of Social Psychology, 7*(1), 241–282. https://doi.org/10.1080/14792779643000038

Konjedi, S., & Maleeh, R. (2020). Sleep and mindfulness meditation as they relate to false memory. *Psychological Research, 84*(4), 1084–1111. https://doi.org/10.1007/s00426-018-1098-0

Kroenke, K., & Spitzer, R. L. (2002). The PHQ-9: A new depression diagnostic and severity measure. *Psychiatric Annals, 32*(9), 509–515. https://doi.org/10.3928/0048-5713-20020901-06

Krusche, A., Cyhlarova, E., King, S., & Williams, J. M. G. (2012). Mindfulness online: A preliminary evaluation of the feasibility of a web-based mindfulness course and the impact on stress. *BMJ Open, 2*(3), e000803. https://doi.org/10.1136/bmjopen-2011-000803

Krusche, A., Cyhlarova, E., & Williams, J. M. G. (2013). Mindfulness online: An evaluation of the feasibility of a web-based mindfulness course for stress, anxiety and depression. *BMJ Open, 3*(11), e003498. https://doi.org/10.1136/bmjopen-2013-003498

Kudesia, R. S. (2019). Mindfulness as metacognitive practice. *Academy of Management Review, 44*(2), 405–423. https://doi.org/10.5465/amr.2015.0333

Kudesia, R. S., & Lau, J. (2020). *Metacognitive practice: Understanding mindfulness as repeated attempts to understand mindfulness*. In S. K. Dhiman (Ed.), The Routledge Companion to Mindfulness at Work (1st ed., pp. 39–53). Routledge. https://doi.org/10.4324/9780429244667-3

Lal, V. N., & Jayan, C. (2019). Correlates of dispositional mindfulness: A theoretical meta-analysis. *Indian Journal of Positive Psychology, 10*(3), 192–200.

Law, R., & Clow, A. (2020). *Chapter Eight—Stress, the cortisol awakening response and cognitive function*. In A. Clow & N. Smyth (Eds.), International Review of Neurobiology (Vol. 150, pp. 187–217). Academic Press. https://doi.org/10.1016/bs.irn.2020.01.001

Lindsay, E. K., & Creswell, J. D. (2017). Mechanisms of mindfulness training: Monitor and Acceptance Theory (MAT). *Clinical Psychology Review, 51*, 48–59. https://doi.org/10.1016/j.cpr.2016.10.011

Lindsay, E. K., & Creswell, J. D. (2019). Mindfulness, acceptance, and emotion regulation: Perspectives from Monitor and Acceptance Theory (MAT). *Current Opinion in Psychology, 28*, 120–125. https://doi.org/10.1016/j.copsyc.2018.12.004

Lomas, T., Medina, J. C., Ivtzan, I., Rupprecht, S., & Eiroa-Orosa, F. J. (2019). Mindfulness-based interventions in the workplace: An inclusive systematic review and meta-analysis of their impact upon wellbeing. *The Journal of Positive Psychology, 14*(5), 625–640. https://doi.org/10.1080/17439760.2018.1519588

Luethi, M., Meier, B., & Sandi, C. (2009). Stress effects on working memory, explicit memory, and implicit memory for neutral and emotional stimuli in healthy men. *Frontiers in Behavioral Neuroscience, 2*. https://doi.org/10.3389/neuro.08.005.2008

Lukasik, K. M., Waris, O., Soveri, A., Lehtonen, M., & Laine, M. (2019). The relationship of anxiety and stress with working memory performance in a large non-depressed sample. *Frontiers in Psychology, 10*. https://doi.org/10.3389/fpsyg.2019.00004

Lukoff, K., Lyngs, U., Gueorguieva, S., Dillman, E. S., Hiniker, A., & Munson, S. A. (2020). From ancient contemplative practice to the app store: Designing a digital container for mindfulness. *Proceedings of the 2020 ACM Designing Interactive Systems Conference*, 1551–1564. https://doi.org/10.1145/3357236.3395444

Lustria, M. L. A., Cortese, J., Noar, S. M., & Glueckauf, R. L. (2009). Computer-tailored health interventions delivered over the web: Review and analysis of key components. *Patient Education and Counseling, 74*(2), 156–173. https://doi.org/10.1016/j.pec.2008.08.023

Lykins, E. L. B., Baer, R. A., & Gottlob, L. R. (2012). Performance-based tests of attention and memory in long-term mindfulness meditators and demographically matched nonmeditators. *Cognitive Therapy and Research, 36*(1), 103–114. https://doi.org/10.1007/s10608-010-9318-y

Malinowski, P., & Lim, H. J. (2015). Mindfulness at work: Positive affect, hope, and optimism mediate the relationship between dispositional mindfulness, work engagement, and well-being. *Mindfulness, 6*(6), 1250–1262. https://doi.org/10.1007/s12671-015-0388-5

Makowski, D., Sperduti, M., Lavallée, S., Nicolas, S., & Piolino, P. (2019). Dispositional mindfulness attenuates the emotional attentional blink. *Consciousness and Cognition, 67*, 16–25. https://doi.org/10.1016/j.concog.2018.11.004

Maramis, M. M., Mahajudin, M. S., & Khotib, J. (2021). Impaired cognitive flexibility and working memory precedes depression: A rat model to study depression. *Neuropsychobiology, 80*(3), 225–233. https://doi.org/10.1159/000508682

Marteau, T. M., & Bekker, H. (1992). The development of a six-item short-form of the state scale of the Spielberger State—Trait Anxiety Inventory (STAI). *British Journal of Clinical Psychology, 31*(3), 301–306. https://doi.org/10.1111/j.2044-8260.1992.tb00997.x

Matthews, G., & Campbell, S. E. (2010). Dynamic relationships between stress states and working memory. *Cognition and Emotion, 24*(2), 357–373. https://doi.org/10.1080/02699930903378719

McCormick, C. B., Dimmitt, C., & Sullivan, F. R. (2013). *Metacognition, learning, and instruction*. In Handbook of psychology: Educational psychology, Vol. 7, 2nd ed (pp. 69–97). John Wiley & Sons, Inc.

McCrae, R. R., & Costa Jr., P. T. (2008). *The five-factor theory of personality*. In Handbook of personality: Theory and research, 3rd ed (pp. 159–181). The Guilford Press.

Mettler, J., Carsley, D., Joly, M., & Heath, N. L. (2019). Dispositional mindfulness and adjustment to university. *Journal of College Student Retention: Research, Theory & Practice, 21*(1), 38–52. https://doi.org/10.1177/1521025116688905

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex “frontal lobe” tasks: A latent variable analysis. *Cognitive Psychology, 41*(1), 49–100. https://doi.org/10.1006/cogp.1999.0734

Mizoguchi, K., Yuzurihara, M., Ishige, A., Sasaki, H., Chui, D.-H., & Tabira, T. (2000). Chronic stress induces impairment of spatial working memory because of prefrontal dopaminergic dysfunction. *Journal of Neuroscience, 20*(4), 1568–1574. https://doi.org/10.1523/JNEUROSCI.20-04-01568.2000

Moore, A., & Malinowski, P. (2009). Meditation, mindfulness and cognitive flexibility. *Consciousness and Cognition, 18*(1), 176–186. https://doi.org/10.1016/j.concog.2008.12.008

Moran, T. P. (2016). Anxiety and working memory capacity: A meta-analysis and narrative review. Psychological Bulletin, 142, 831–864. https://doi.org/10.1037/bul0000051

Morawska, A., Tometzki, H., & Sanders, M. R. (2014). An evaluation of the efficacy of a triple p-positive parenting program podcast series. *Journal of Developmental & Behavioral Pediatrics, 35*(2), 128. https://doi.org/10.1097/DBP.0000000000000020

Morrison, A. B., & Jha, A. P. (2015). *Mindfulness, Attention, and Working Memory*. In B. D. Ostafin, M. D. Robinson, & B. P. Meier (Eds.), Handbook of Mindfulness and Self-Regulation (pp. 33–45). Springer. https://doi.org/10.1007/978-1-4939-2263-5_4

Mrazek, M. D., Franklin, M. S., Phillips, D. T., Baird, B., & Schooler, J. W. (2013). Mindfulness training improves working memory capacity and GRE performance while reducing mind wandering. *Psychological science 24*(5), 776–781. https://doi.org/10.1177/0956797612459659

O'Connor, S., Daly, C. S., MacArthur, J., Borglin, G., & Booth, R. G. (2020). Podcasting in nursing and midwifery education: An integrative review. *Nurse Education in Practice, 47*, 102827. https://doi.org/10.1016/j.nepr.2020.102827

Odell, P. M., Korgen, K. O., Schumacher, P., & Delucchi, M. (2000). Internet Use Among Female and Male College Students. *CyberPsychology & Behavior, 3*(5), 855–862. https://doi.org/10.1089/10949310050191836

O'Neil, H. F., & Abedi, J. (1996). Reliability and validity of a state metacognitive inventory: potential for alternative assessment. *The Journal of Educational Research, 89*(4), 234–245.

Osaka, M., Komori, M., Morishita, M., & Osaka, N. (2007). Neural bases of focusing attention in working memory: An fMRI study based on group differences. *Cognitive, Affective, & Behavioral Neuroscience, 7*(2), 130–139. https://doi.org/10.3758/CABN.7.2.130

Pardilla-Delgado, E., & Payne, J. D. (2017). The Deese-Roediger-McDermott (DRM) Task: A simple cognitive paradigm to investigate false memories in the laboratory. *Journal of Visualized Experiments : JoVE*, 119. https://doi.org/10.3791/54793

Paris, S. G., & Paris, A. H. (2001). Classroom applications of research on self-regulated learning. *Educational Psychologist, 36*(2), 89–101. https://doi.org/10.1207/S15326985EP3602_4

Pedone, R., Semerari, A., Riccardi, I., Procacci, M., Nicolò, G., & Carcione, A. (2017). Development of a self-report measure of metacognition: The Metacognition Self-Assessment Scale (MSAS). Instrument description and factor structure. *Clinical Neuropsychiatry: Journal of Treatment Evaluation, 14*, 185–194. doi: 10.1080/23279095.2019.1671843

Ramler, T. R., Tennison, L. R., Lynch, J., & Murphy, P. (2016). Mindfulness and the college transition: the efficacy of an adapted Mindfulness-Based Stress Reduction intervention in

fostering adjustment among first-year students. *Mindfulness, 7*(1), 179–188. https://doi.org/10.1007/s12671-015-0398-3

Reber, R. (2014). *Mindfulness in Education*. In The Wiley Blackwell Handbook of Mindfulness (pp. 1054–1070). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118294895.ch54

Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., & Yiend, J. (1997). `Oops!': Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. *Neuropsychologia, 35*(6), 747–758. https://doi.org/10.1016/S0028-3932(97)00015-8

Robins, T. G., Roberts, R. M., & Sarris, A. (2018). The role of student burnout in predicting future burnout: Exploring the transition from university to the workplace. *Higher Education Research & Development, 37*(1), 115–130. https://doi.org/10.1080/07294360.2017.1344827

Robotham, D., & Julian, C. (2006). Stress and the higher education student: A critical review of the literature. *Journal of Further and Higher Education, 30*(2), 107–117. https://doi.org/10.1080/03098770600617513

Rose, E. J., & Ebmeier, K. P. (2006). Pattern of impaired working memory during major depression. *Journal of Affective Disorders, 90*(2), 149–161. https://doi.org/10.1016/j.jad.2005.11.003

Sahdra, B. K., MacLean, K. A., Ferrer, E., Shaver, P. R., Rosenberg, E. L., Jacobs, T. L., Zanesco, A. P., King, B. G., Aichele, S. R., Bridwell, D. A., Mangun, G. R., Lavy, S., Wallace, B. A., & Saron, C. D. (2011). Enhanced response inhibition during intensive

meditation training predicts improvements in self-reported adaptive socioemotional functioning. *Emotion, 11*, 299–312. https://doi.org/10.1037/a0022764

Sale, M. V., Ridding, M. C., & Nordstrom, M. A. (2008). Cortisol inhibits neuroplasticity induction in human motor cortex. *Journal of Neuroscience, 28*(33), 8285–8293. https://doi.org/10.1523/JNEUROSCI.1963-08.2008

Sanada, K., Montero-Marin, J., Alda Díez, M., Salas-Valero, M., Pérez-Yus, M. C., Morillo, H., Demarzo, M. M. P., García-Toro, M., & García-Campayo, J. (2016). Effects of mindfulness-based interventions on salivary cortisol in healthy adults: A meta-analytical review. *Frontiers in Physiology, 7*. https://www.frontiersin.org/articles/10.3389/fphys.2016.00471

Santorelli, S. F., Meleo-Meyer, F., Koerbel, L., & Kabat-Zinn, J. (2017). *Mindfulness-Based Stress Reduction (MBSR) Authorized Curriculum Guide*. University of Massachusetts Medical School Center for Mindfulness in Medicine, Health Care, and Society.

Schwarzer, R. (2008). Modeling health behavior change: How to predict and modify the adoption and maintenance of health behaviors. *Applied Psychology, 57*(1), 1–29. https://doi.org/10.1111/j.1464-0597.2007.00325.x

Sellars, J. (2018). An Ancient Technology of the Self. In *Ethics and Self-Cultivation*. Routledge.

Segal, Z., Williams, M., & Teasdale, J. (2018). *Mindfulness-Based Cognitive Therapy for Depression, Second Edition*. Guilford Publications.

Sezer, I., Pizzagalli, D. A., & Sacchet, M. D. (2022). Resting-state fMRI functional connectivity and mindfulness in clinical and non-clinical contexts: A review and synthesis.

Neuroscience and Biobehavioral Reviews 135, 104583. https://doi.org/10.1016/j.neubiorev.2022.104583

Shemesh, L., Mendelsohn, A., Panitz, D.Y., & Berkovich-Ohana, A. (2022). Enhanced declarative memory in long-term mindfulness practitioners. *Psychological Research (2022)*. https://doi.org/10.1007/s00426-022-01642-6

Simione, L., Raffone, A., & Mirolli, M. (2021). Acceptance, and not its interaction with attention monitoring, increases psychological well-being: Testing the Monitor and Acceptance Theory of Mindfulness. *Mindfulness, 12*(6), 1398–1411. https://doi.org/10.1007/s12671-021-01607-7

Solem, S., Thunes, S. S., Hjemdal, O., Hagen, R., & Wells, A. (2015). A metacognitive perspective on mindfulness: An empirical investigation. *BMC Psychology, 3*(1), 24. https://doi.org/10.1186/s40359-015-0081-4

Sousa, G. M. de, Lima-Araújo, G. L. de, Araújo, D. B. de, & Sousa, M. B. C. de. (2021). Brief mindfulness-based training and mindfulness trait attenuate psychological stress in university students: A randomized controlled trial. *BMC Psychology, 9*(1), 21. https://doi.org/10.1186/s40359-021-00520-x

Souza, A. S., Rerko, L., Lin, H.-Y., & Oberauer, K. (2014). Focused attention improves working memory: Implications for flexible-resource and discrete-capacity models. *Attention, Perception, & Psychophysics, 76*(7), 2080–2102. https://doi.org/10.3758/s13414-014-0687-2

Spijkerman, M. P. J., Pots, W. T. M., & Bohlmeijer, E. T. (2016). Effectiveness of online mindfulness-based interventions in improving mental health: A review and meta-analysis

of randomised controlled trials. *Clinical Psychology Review 45*, 102–114. https://doi.org/10.1016/j.cpr.2016.03.009

Steckler, A., Allegrante, J. P., Altman, D., Brown, R., Burdine, J. N., Goodman, R. M., & Jorgensen, C. (1995). Health education intervention strategies: recommendations for future research. *Health Education Quarterly, 22*(3), 307–328. https://doi.org/10.1177/109019819402200305

Strohmaier, S. (2020). The relationship between doses of mindfulness-based programs and depression, anxiety, stress, and mindfulness: A dose-response meta-regression of randomized controlled trials. *Mindfulness, 11*(6), 1315–1335. https://doi.org/10.1007/s12671-020-01319-4

Sun, S., Yao, Z., Wei, J., & Yu, R. (2015). Calm and smart? A selective review of meditation effects on decision making. *Frontiers in Psychology 6*, 1059. doi: 10.3389/fpsyg.2015.01059.

Taber-Thomas, B., & Pérez-Edgar, K. (2016). Emerging adulthood brain development. In Arnett, J. J, *The Oxford handbook of emerging adulthood* (pp. 126-141). Oxford University Press.

Tanay, G., & Bernstein, A. (2013). State Mindfulness Scale (SMS): Development and initial validation. *Psychological Assessment, 25*, 1286–1299. https://doi.org/10.1037/a0034044

Tang, Y.Y., Ma, Y., Wang, J., Fan, Y., Feng, S., Lu, Q., Yu, Q., Sui, D., Rothbart, M. K., Fan, M., & Posner, M. I. (2007). Short-term meditation training improves attention and self-regulation. *Proceedings of the National Academy of Sciences, 104*(43), 17152–17156. https://doi.org/10.1073/pnas.0707678104

Tang, Y.Y., Hölzel, B. K., & Posner, M. I. (2015). The neuroscience of mindfulness meditation. Nature Reviews Neuroscience, 16(4), Article 4. https://doi.org/10.1038/nrn3916

Teper, R., & Inzlicht, M. (2013). Meditation, mindfulness and executive control: The importance of emotional acceptance and brain-based performance monitoring. *Social Cognitive and Affective Neuroscience, 8*(1), 85–92. https://doi.org/10.1093/scan/nss045

Turner-McGrievy, G. M., Campbell, M. K., Tate, D. F., Truesdale, K. P., Bowling, J. M., & Crosby, L. (2009). Pounds off digitally study: A randomized podcasting weight-loss intervention. *American Journal of Preventive Medicine, 37*(4), 263–269. https://doi.org/10.1016/j.amepre.2009.06.010

Ugwoke, S. C., Eseadi, C., Igbokwe, C. C., Chiaha, G. T. U., Nwaubani, O. O., Orji, C. T., Ugwuanyi, L. T., Chukwuma, I. S., Edikpa, E. C., Ogakwu, V. N., Onu, E. A., Agu, P., Nwobi, U. A., Omeke, F., Okeke, F. C., Ezema, R. N., & Abugu, L. I. (2017). Effects of a rational-emotive health education intervention on stress management and irrational beliefs among technical college teachers in Southeast Nigeria. *Medicine, 96*(31), e7658. https://doi.org/10.1097/MD.0000000000007658

Uziel, L. (2007). Individual differences in the social facilitation effect: A review and meta-analysis. *Journal of Research in Personality, 41*(3), 579–601. https://doi.org/10.1016/j.jrp.2006.06.008

Van Daele, T., Hermans, D., Van Audenhove, C., & Van den Bergh, O. (2012). Stress reduction through psychoeducation: A meta- analytic review. *Health Education & Behavior, 39*(4), 474–485. https://doi.org/10.1177/1090198111419202

Van Vugt, M. K., & Jha, A. P. (2011). Investigating the impact of mindfulness meditation training on working memory: A mathematical modeling approach. *Cognitive, Affective, & Behavioral Neuroscience, 11*(3), 344–353. https://doi.org/10.3758/s13415-011-0048-8

Vella, E., & McIver, S. (2019). Reducing stress and burnout in the public-sector work environment: A mindfulness meditation pilot study. *Health Promotion Journal of Australia, 30*(2), 219–227. https://doi.org/10.1002/hpja.192

Vøllestad, J., Nielsen, M. B., & Nielsen, G. H. (2012) Mindfulness- and acceptance-based interventions for anxiety disorders: A systematic review and meta-analysis. *British Journal of Clinical Psychology 51*, 239-260. https://doi.org/10.1111/j.2044-8260.2011.02024.x.

Wang, Y., Xiao, L., Gong, W., Chen, Y., Lin, X., Sun, Y., Wang, N., Wang, J., & Luo, F. (2022). Mindful non-reactivity is associated with improved accuracy in attentional blink testing: A randomized controlled trial. *Current Psychology, 41*(12), 8908–8920. https://doi.org/10.1007/s12144-021-01377-4

Warriner, A. B., Kuperman, V., & Brysbaert, M. (2013). Norms of valence, arousal, and dominance for 13,915 English lemmas. *Behavior Research Methods, 45*(4), 1191–1207. https://doi.org/10.3758/s13428-012-0314-x

Watkins, E. (2004). Adaptive and maladaptive ruminative self-focus during emotional processing. *Behaviour Research and Therapy, 42*(9), 1037–1052. https://doi.org/10.1016/j.brat.2004.01.009

Williams, J. M. G., Mathews, A., & MacLeod, C. (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin, 120*, 3–24. https://doi.org/10.1037/0033-2909.120.1.3

Wilson, B. M., Mickes, L., Stolarz-Fantino, S., Evrard, M., & Fantino, E. (2015). Increased false-memory susceptibility after mindfulness meditation. *Psychological Science 26*(10), 1567-1573. https://doi.org/10.1177%2F0956797615593705.

Zeidan, F., Johnson, S. K., Diamond, B. J., David, Z., & Goolkasian, P. (2010). Mindfulness meditation improves cognition: Evidence of brief mental training. *Consciousness and Cognition, 19*(2), 597–605. https://doi.org/10.1016/j.concog.2010.03.014

Zhou, H., Liu, H., & Deng, Y. (2020). Effects of short-term mindfulness-based training on executive function: Divergent but promising. *Clinical Psychology & Psychotherapy, 27*(5), 672–685. https://doi.org/10.1002/cpp.2453

Zimmaro, L. A., Salmon, P., Naidu, H., Rowe, J., Phillips, K., Rebholz, W. N., Giese-Davis, J., Cash, E., Dreeben, S. J., Bayley-Veloso, R., Jablonski, M. E., Hicks, A., Siwik, C., & Sephton, S. E. (2016). Association of dispositional mindfulness with stress, cortisol, and well-being among university undergraduate students. *Mindfulness, 7*(4), 874–885. https://doi.org/10.1007/s12671-016-0526-8

Appendix A

31-Day, 15-Minute Daily Online Mindfulness-Based Intervention

A Brief Standardized Mindfulness Meditation Training and Practice Protocol

*Instructions Adapted from *Isbel & Summers, 2017*

Mindfulness Meditative Practice Module

This adapted mindfulness-based intervention (MBI) involves 31 days of 15 minutes of daily online mindfulness meditative practice (MMP). The MBI was administered via an online web module (see sample images below). Participants logged in to the website using their assigned credentials and completed each day's MMP module. This web module served both as the user interface, as well as a convenient way for researchers to track both compliance and subjective experience, and interact with participants to offer guidance. In this way, our web module at least partially simulates the in-person design of the original 8-week MBI (Isbel & Summers, 2017) by providing feedback mechanisms between researcher and participant.

Pre-Recorded Guided Meditation – Audio File

Subjects were presented with the same 15-minute recorded audio MBI daily, for a total of 31 days. Participants were verbally guided through the instructions listed in **Table A** for their daily sitting meditation. The audio recording contained only a deeper-register male voice (the voice of a principal researcher) annunciating the instructions in a soft, slow-paced, calm – yet strong and alert – manner.

Online Participant-Researcher Interactive Feedback

Feedback from participants was solicited after each daily session was completed via the web module. Both fixed-choice and open feedback responses were sought from participants (see **Methods** section). Additionally, participants were able to communicate any questions they may have each day about their mindfulness practice to the researcher. This proceeded via a questions prompt at the end of each session which reads: *'If you have any questions about the*

practice or require clarification about anything please ask the researcher here. We will leave you a general response which is displayed to you and all other participants prior to your next session once you log in.'

Thus, if a participant had any questions after their session or required clarification, they had the opportunity to get feedback from the researchers – and the researcher's response were then presented to them in a pop-up-style notification prior to commencement of their next daily session. All researcher responses were aligned with the key instructions in **Table A**; researchers tried to stay as closely to the principles in the script and key instructions as possible. All clarifications were efficient and non-elaborative, only providing information that was relevant and aligned with the key instructions of the MBI.

31-Day, 15-Minute Daily Online MBI Instructions

Table A
Sitting Exercise Instructions.

Instruction Phase	Key Instruction	Instructions to participants
Preparation	Assume a comfortable, erect posture	Sit cross-legged on a cushion placed on the floor, or if this is uncomfortable, in a straight-backed chair with your feet placed flat on the floor. Sit in a relaxed, erect posture, with your hands resting either in your lap or resting on your knees. Your eyes can be either closed, or slightly open with the gaze cast slightly down. Adopt a comfortable and alert posture you are capable of maintaining for the duration of the session.
Basic technique	Be attentive to the sensations arising with the breath at the abdomen	Direct your attention to the sensations occurring at the abdomen with each breath. Do not intentionally breathe faster or slower, deeper or shallower, but let the breath remain natural. Observe the sensations of movement or tightness that arise with the rising and falling of the abdomen. As you breathe in, try to notice the beginning, the middle, and the end of the rising movement. As

		you breathe out, try to notice the beginning, the middle, and the end of the falling movement. Notice these physical sensations without thinking about them in any way
	Note the rising and falling with mental labelling	Make a soft mental note of ‘rising’ while attending to the sensations of the rising abdomen, and ‘falling’ while attending to the falling sensations. Without thinking about these sensations or the fact that you are attending to them, simply be aware of the sensations of rising and falling as closely as possible while gently noting ‘rising, falling.’
	Return again and again to the breath	At the beginning, you will find it difficult to remain attentive to each successive rising and falling movement as it occurs. Remember that this is a learning process, and that the movements of the breath are always present. Simply return your attention with accuracy and clarity to these sensations whenever the mind wanders
Dealing with distraction	Note thoughts as soon as they arise	Mindfulness is not the absence of thought. Distracting thoughts will naturally arise. Simply try to be mindful of thoughts when they arise. When a thought occurs, without getting caught up in or following the thought, simply be aware of the thought. Use the mental label ‘thinking’ to note it, and return your attention to the sensations of rising and falling. Do not follow thoughts, feelings, or emotions when they arise. Do not think about your thoughts. Do not worry if your thoughts are good or bad. Simply note ‘thinking’ and return to the rising and falling of the abdomen You may not be aware for some time that your mind has wandered, but as soon as you become aware of distraction, note ‘thinking,’ and return

		to the rising and falling of the abdomen. If you notice many
	Do not be concerned with other objects	thoughts, this is mindfulness. Being aware of thoughts is mindfulness. Being lost in thoughts is distraction. Remain attentive to the rising and falling. Only notice other objects when they draw your attention away from the rising and falling. For example, if a loud sound occurs, be aware of the experience of hearing, without thinking about what caused the sound. Mentally note 'hearing' and once the sound has passed, return to the rising and falling. Do not seek out or be concerned with other objects.
Stay relaxed and balanced	Do not worry about pleasant or unpleasant experiences	Do not be concerned whether your experience is pleasant or unpleasant. You will experience both pleasant and unpleasant sensations while paying attention to your body and mind. Both types of feeling will arise and pass away, so try not to hold onto pleasant feelings or push unpleasant ones away. Simply remain mindful and mentally note everything that occurs
	Stay relaxed	Keep the mental label simple, calm, and natural. While we may experience a bewildering range of thoughts, hopes, concerns, doubts and mental images, simply label them 'thinking' as they arise, and return to the rising and falling movements of the abdomen.
Dealing with difficulties	Direct your attention to discomfort when it arises	After sitting for a while, you may experience persistent feelings of tiredness, discomfort, itching, and pain. At this time, direct your attention to these feelings, maintaining awareness of the sensations by noting 'pain,' 'aching,' or 'itching.' Remain mindful of such sensations without worry or concern. If the sensations fade away, return to the rising and falling. If the sensations continue to increase and you wish to move, change your

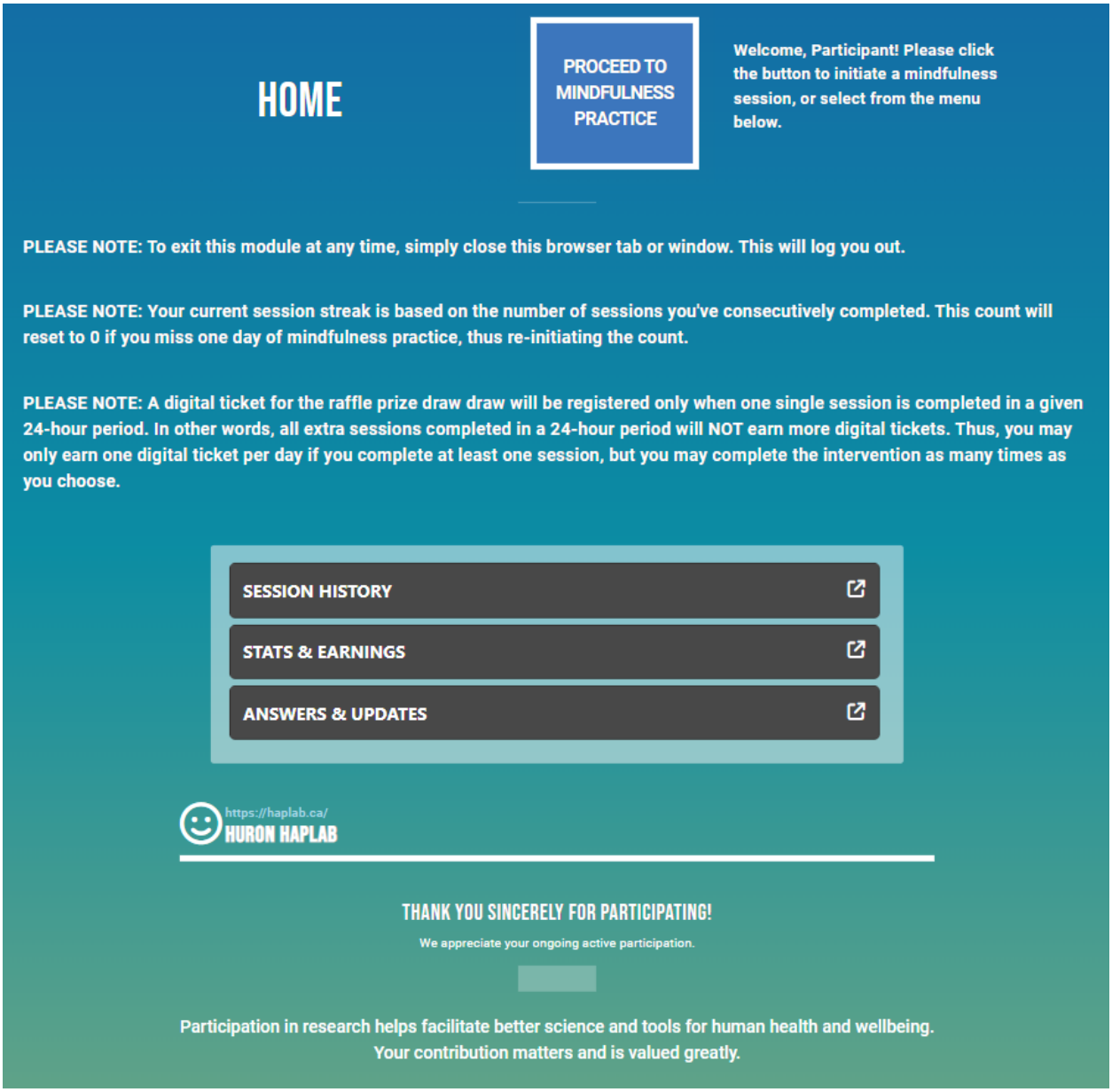
	Move slowly and mindfully	position mindfully in the following manner If you intend to scratch an itch on your leg, make a mental note 'intending.' When lifting the hand, note 'lifting.' When moving the hand, note 'moving.' In extending a finger, note 'moving.' When touching the leg, 'touching,' when scratching, 'scratching.' When intending to withdraw one's hand, note 'intending.' When withdrawing the hand back, 'moving,' and in resting the hand in your lap, 'touching.' Do so slowly, directing your attention to the mere sensations that arise with each act. Apply the same mindful attention to other actions, such as adjusting your posture, or swallowing saliva.
Developing proficiency	Continue to note everything that occurs	During the sitting session, simply remain continuously attentive to the sensations of rising and falling as they occur, trying to notice them closer and closer. As thoughts, sounds, feelings, doubts, wishes, and bodily sensations arise, simply note them by applying a soft mental label, and return to the sensations of the rising and falling of the abdomen. If you notice a break between the rising and falling movements, at that time direct your attention to the body as a whole, and be aware of the sitting posture, noting 'rising, falling, sitting,' or 'rising, sitting, falling, sitting.'
	Balance your effort	Practice in a relaxed but alert manner. Avoid becoming tense through excessive striving, or lethargic and dull by relaxing too much. Seek to balance your effort, calmly remaining attentive to the rising and falling movements while noting when your attention wanders or is drawn away
	Relax the use of labelling	Mental labelling helps direct your attention to the sensations you are

	Relax in Awareness	noting. With practice attention begins to rest evenly upon the rising and falling, so the label can be slowly relaxed. Eventually you may continue without the need for noting. After developing proficiency through sustained practice, gradually relax your focus on the sensations accompanying the breath and open your awareness to all of your experience. Gently recognise the knowing quality of awareness. Rest in open awareness free of fixation upon any object or thought.
Ending the session	End your session mindfully	When you wish to end your session, be mindful of this intention, noting 'intending.' Then be mindful of the actions of body and mind as you arise from your sitting posture.

Adapted from Isbel & Summers (2017).

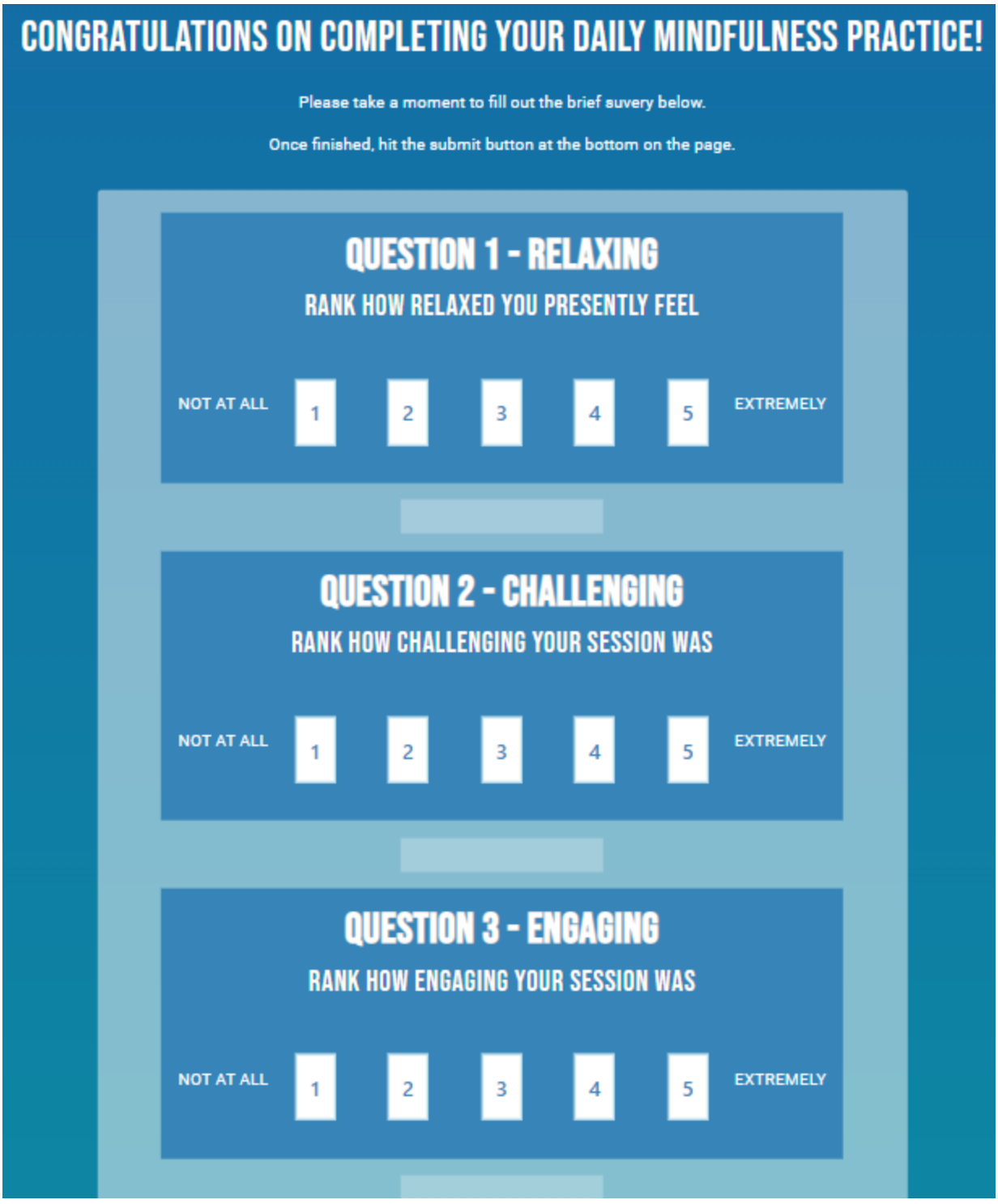
Mindfulness Web Module Sample Images

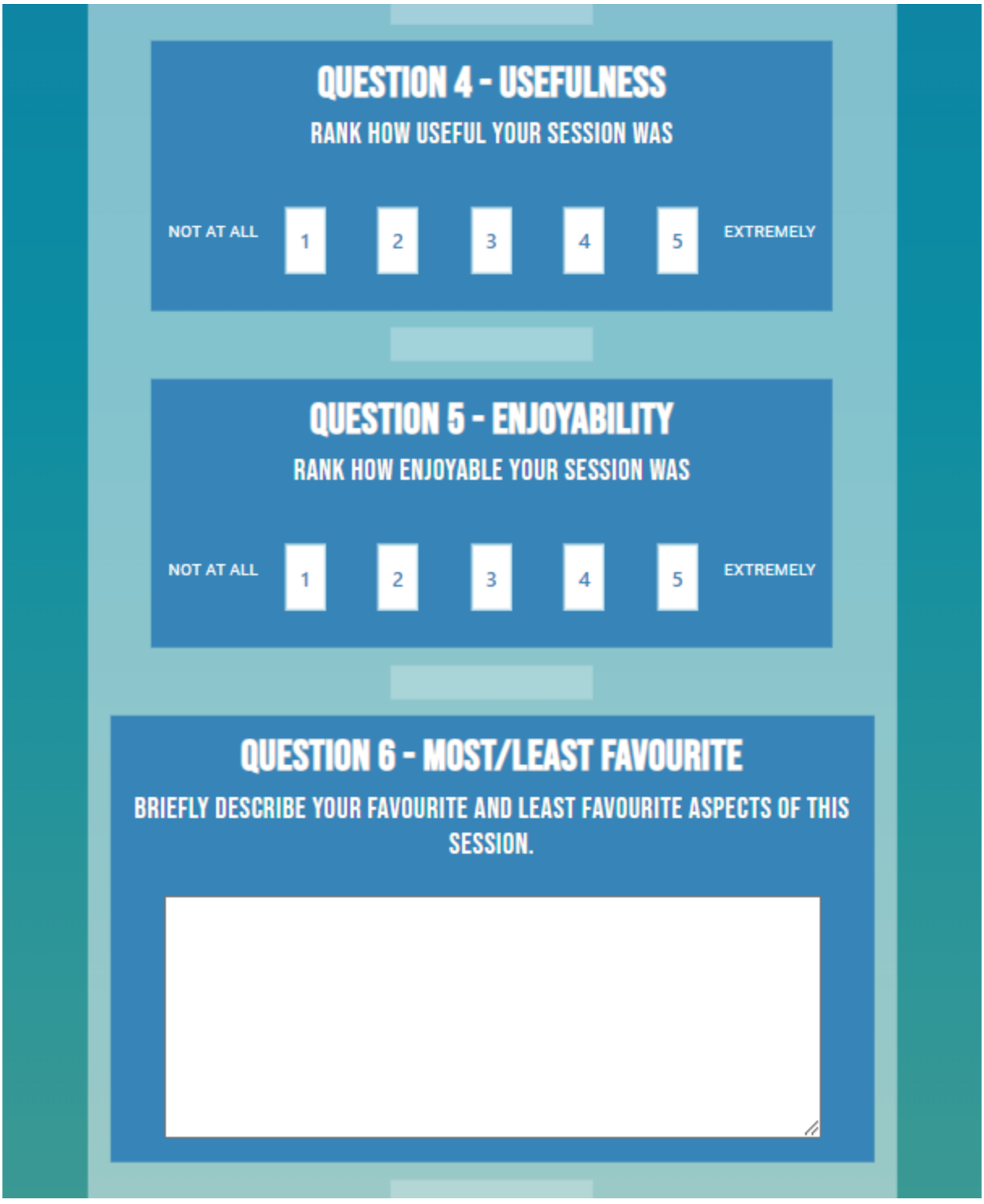
The below images are samples of the various screens of our online web module in sequential order.

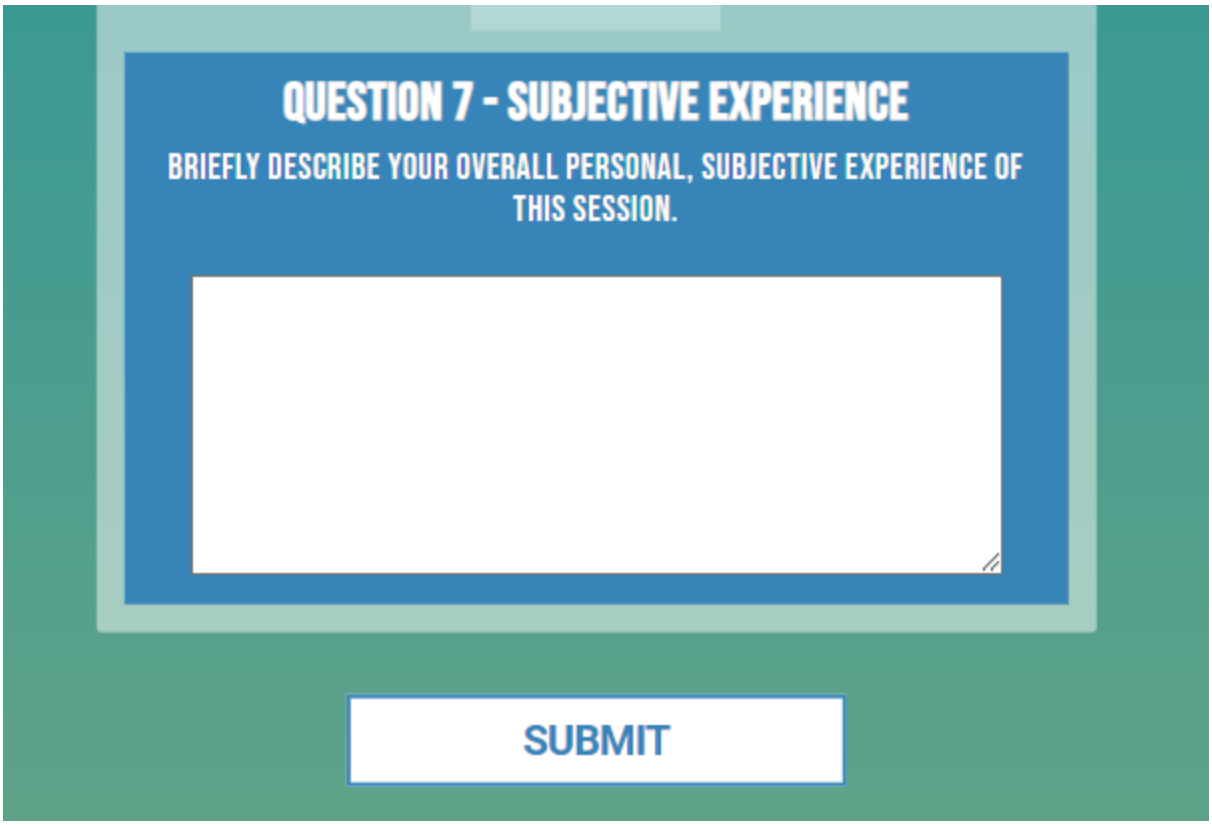

HOME
PROCEED TO MINDFULNESS PRACTICE
Welcome, Participant! Please click the button to initiate a mindfulness session, or select from the menu below.
PLEASE NOTE: To exit this module at any time, simply close this browser tab or window. This will log you out.
PLEASE NOTE: Your current session streak is based on the number of sessions you've consecutively completed. This count will reset to 0 if you miss one day of mindfulness practice, thus re-initiating the count.
PLEASE NOTE: A digital ticket for the raffle prize draw draw will be registered only when one single session is completed in a given 24-hour period. In other words, all extra sessions completed in a 24-hour period will NOT earn more digital tickets. Thus, you may only earn one digital ticket per day if you complete at least one session, but you may complete the intervention as many times as you choose.
SESSION HISTORY
STATS & EARNINGS
ANSWERS & UPDATES
https://haplab.ca/
HURON HAPLAB
THANK YOU SINCERELY FOR PARTICIPATING!
We appreciate your ongoing active participation.
Participation in research helps facilitate better science and tools for human health and wellbeing.
Your contribution matters and is valued greatly.


NEWS INFO & UPDATES
If any participants asked questions in their prior sessions, responses from the researchers will appear below. A record of all prior answers & updates can be found in a tab labeled "Answers & Updates" on your home screen.
PLEASE NOTE: To exit this module at any time, simply close this browser tab or window. This will log you out.
RESPONSE RE: DAILY SESSION REPETITIVE
Hey all, someone mentioned that having the same daily session to listen to each day is getting a bit repetitive. I just wanted to acknowledge this point as I completely understand -- please note that this intervention is still in development, so this is basically intentional -- though I do apologize for the repetitiveness. I want to make sure the key instructions are well-ingrained into people's minds and part of that involves repetition over time. So, while I understand it may be slightly annoying, there's a method to our madness -- so I hope you can stick with us here! My suggestion would be to try not to focus on the repetitiveness too much, but instead note your annoyance with repetitiveness in the moment and let train of thought go without getting caught up. I hope this helps!
CLICK HERE TO BEGIN MEDITATION
RETURN TO HOME MENU
https://haplab.ca/
HURON HAPLAB
THANK YOU SINCERELY FOR PARTICIPATING!
We appreciate your ongoing active participation.
Participation in research helps facilitate better science and tools for human health and wellbeing.
Your contribution matters and is valued greatly.


MEDITATION
PLEASE ENJOY YOUR MINDFULNESS PRACTICE!
When you are in a comfortable, calm location where you'll be undisturbed and able to listen attentively for the duration of this session, please click the play button below to proceed.
PLEASE CLICK THE PLAY BUTTON BELOW TO BEGIN YOUR MINDFULNESS MEDITATION
15:00 / 15:00
SUBMIT SESSION
SCRAP SESSION
https://haplab.ca/
HURON HAPLAB
THANK YOU SINCERELY FOR PARTICIPATING!
We appreciate your ongoing active participation.
Participation in research helps facilitate better science and tools for human health and wellbeing.
Your contribution matters and is valued greatly.


CONGRATULATIONS ON COMPLETING YOUR DAILY MINDFULNESS PRACTICE!
Please take a moment to fill out the brief suvery below.
Once finished, hit the submit button at the bottom on the page.
QUESTION 1 - RELAXING
RANK HOW RELAXED YOU PRESENTLY FEEL
NOT AT ALL
1
2
3
4
5
EXTREMELY
QUESTION 2 - CHALLENGING
RANK HOW CHALLENGING YOUR SESSION WAS
NOT AT ALL
1
2
3
4
5
EXTREMELY
QUESTION 3 - ENGAGING
RANK HOW ENGAGING YOUR SESSION WAS
NOT AT ALL
1
2
3
4
5
EXTREMELY


QUESTION 4 - USEFULNESS
RANK HOW USEFUL YOUR SESSION WAS
NOT AT ALL
1
2
3
4
5
EXTREMELY
QUESTION 5 - ENJOYABILITY
RANK HOW ENJOYABLE YOUR SESSION WAS
NOT AT ALL
1
2
3
4
5
EXTREMELY
QUESTION 6 - MOST/LEAST FAVOURITE
BRIEFLY DESCRIBE YOUR FAVOURITE AND LEAST FAVOURITE ASPECTS OF THIS SESSION.


QUESTION 7 - SUBJECTIVE EXPERIENCE
BRIEFLY DESCRIBE YOUR OVERALL PERSONAL, SUBJECTIVE EXPERIENCE OF THIS SESSION.
SUBMIT


QUESTIONS/ COMMENTS
If you have any questions or comments for the researchers about your mindfulness practice please submit them using the field below*
*This portion is not required
SKIP FEEDBACK
PLEASE NOTE: To exit this module at any time, simply close this browser tab or window. This will log you out.
SUBMIT RESPONSE
RETURN TO HOME MENU
https://haplab.ca/
HURON HAPLAB
THANK YOU SINCERELY FOR PARTICIPATING!
We appreciate your ongoing active participation.
Participation in research helps facilitate better science and tools for human health and wellbeing.
Your contribution matters and is valued greatly.


THE EFFECTS OF AN AUDITORY-BASED ONLINE INTERVENTION ON COGNITION AND AFFECTIVE PROCESSING
Congratulations on completeing your daily mindfulness practice - and thank you for submitting your feedback!
Your responses have been recorded.
You have also earned one additional entry of your name into the $50 prize raffle at the end of the study.
We thank you sincerely - and look forward to welcoming you again tomorrow!
RETURN TO HOME MENU
To exit, either close this browser tab to log out, or click to return to the home menu.

Curriculum Vitae

Name:	Jordan S. H. Thomson
Secondary School Diploma:	Oakridge High School 2006, London, Ontario
Post-Secondary Diploma:	Law Clerk (2017), Fanshawe College, London, Canada
Experience:	Research Lab Assistant – Winter 2020 CURL Fall Exhibition 2022 Participant at Huron University College in London, Canada – Created digital poster for social media. Honours Thesis Project 2022-2023 – Investigated the effects of a brief 15-minute, 31-day daily online mindfulness-based intervention on cognitive processing, socio-affective functioning, and individual differences.
Awards:	**Dean's Honor List** (2020, 2021, 2022, 2023); ***SCHOLARSHIP***: Transfer School of Excellence – 2019 Academic scholarship ($2000 per annum) ***AWARD***: The Sabina Cole Memorial Award for Biopsychology – 2020-2021 Academic performance award ($130) ***AWARD***: The Professor Mark R. Cole Award for Experimental Psychology – 2021-2022 Academic performance award ($130) ***AWARD***: The Dr. Stephen Erdle Award in Quantitative Psychology – 2021-2022 Academic performance award ($130) ***FELLOWSHIP***: Summer 2023 CURL Research Fellowship Research funding award for Summer 2023 ($1500)
Publications:	Thomson, J. (2023). The effects of an auditory-based 15-minute daily online mindfulness-based intervention on cognitive processing, socio-affective functioning, and dispositional mindfulness. *The Huron University College Journal of Learning and Motivation*. Issue and DOI TBD.